

PROJECTING CROPLAND RENTAL RATE AND ASSET VALUES: USING A HYBRID OF PAST APPROACHES TO HARVEST NEW ESTIMATES

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Approval Form

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PROJECTING CROPLAND RENTAL RATE AND ASSET VALUES: USING A HYBRID OF
PAST APPROACHES TO HARVEST NEW ESTIMATES

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With heartfelt gratitude, ~Beth

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Abstract

The net worth of farming operations has been affected by recent changes in cropland asset values caused by historically low interest rates and by increased net crop receipts that raised rental rates. A simultaneous system of supply and demand equations was identified using past literature to project cropland rental rates from projected net crop receipts and other variables. The estimated elasticity of cropland rental rates with respect to net crop receipts is equal to 1. The projected rental rates were used in an infinite-life capitalization formula to project cropland asset values. Cropland asset values are found to be sensitive to assumptions about future interest rates. A scenario decreasing government payments by \$1 billion resulted in much larger proportional impacts on cropland rental rates and asset values than on the total amount of land used for crop production. Given projected decreases in net crop receipts and increases in interest rates, the model suggests cropland asset values could fall by 41% percent by 2019 from 2014 levels.

I. Introduction

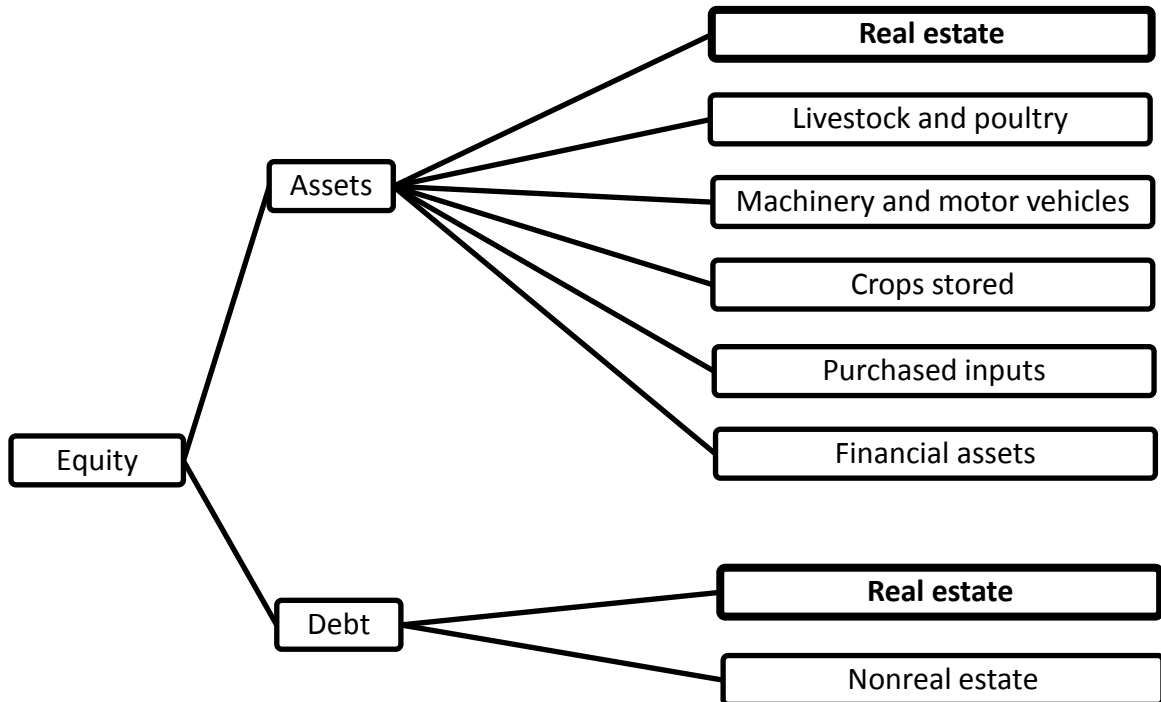
Shelves of books filled with literature on land economics are dedicated to the purpose of understanding the platform upon which we live our lives. Land use, which is any activity land is party to and anything that we build on it, is the interest of this thesis. Over time, world population growth transitioned land from being an abundant resource to a scarce one. Scarce resources require society to make choices about how to best allocate and distribute use. In choosing land for agriculture use, soil characteristics and topography are essential. Soil is one of nature's most valuable gifts because it purifies our water, grows our crops, and stores resources. Understanding the market of land use for crop production allows for analysis of the decisions made in allocating the use of this valuable resource.

Land is a store of farm wealth that families depend on for retirement, life insurance, and inheritance (Nickerson, Morehart, et al. 2012). Changes in the value of land determine how reliable it is as an investment and as a store of wealth. The financial condition of the sector can be measured by the debt-to-asset ratio, rate of return on assets, debt service coverage ratio, and asset turnover. These ratios represent the solvency, profitability, liquidity, and efficiency of the industry. Equity, also known as net worth, is an indicator of wealth generation and is used in the financial ratios. Farm equity is diagramed in figure 1 based on the United States Department of Agriculture (USDA) Economic Research Service (ERS) balance sheet of the U.S. farming sector.

$$\text{Equity} = \text{Assets} - \text{Debt}$$

In 2013 real estate was 82.6% of farm assets and 57.8% of farm debt, making up a significant portion of farm equity (Morehart, Assets, Debt, and Wealth 2015).

Figure 1- Equity Diagram



A notable 2014 Rabobank report discussed the potential for an asset bubble to form in farmland values, which is to say that land as an asset could become inflated beyond its economic value (Liddell 2014). Agriculture land experienced large increases in value over the last decade that have been justified by fundamental economic drivers, and are therefore not the result of an asset bubble, according to Liddell. In the Rabobank report, Liddell stated that “in 2014, key indicators are signaling that the long-term growth pattern needs to change or risk the development of an asset bubble by

extending the value/cost of land beyond its economic capacity to generate returns” (Liddell 2014, 1). This has been a common topic in agriculture of late because of the 1980 farmland bust/farm crisis, and a worry that a new crisis could happen. In the Wall Street Journal it was reported that if farmland values fall, a financial crisis is not expected because income is expected to stay strong and debt levels are low, unlike the 1980s (Newman and Bunge 2014).

The goal of this thesis is to develop an econometric model that projects cropland rental rates, cropland asset value, and farmland real estate value. The model will apply supply and demand theory, the Ricardian theory of rents, and capitalization theory. Improving the method of projecting the value of farmland real estate will improve the projection of key farm sector indicators, giving farmers, policy makers, and market participants more reliable data for making decisions.

The method developed includes a simultaneous equations model for cropland supply and demand to determine cropland rental rates and crop acres. A present value formula is used to estimate cropland asset value, and farmland value is estimated as a function of cropland asset value. Ordinary Least Squares (OLS) regression is used to quantify the relationship between selected economic variables. Equation specifications are kept simple, with a parsimonious selection of right-hand-side variables. Coefficient signs are consistent with economic theory, and implied elasticities appear reasonable.

II. Market Overview

Factors that have increased productivity and other changes that have occurred in the farmland market in the past can lend insight to what might happen in the future. Productivity increases in agriculture have come from many sources but most notably from changes in seed technology, chemical application, and machinery. Other market influences include international trade, financial crises, and government farm programs. The purpose of this chapter is to create a picture of the industry since 1970 and factors that have influenced the farmland market that are important to economists, farmers, landowners, lenders, and policy makers.

By the 1970s hybrid seeds dominated corn acreage with an ability to yield more than conventional seeds, and in the late 1990s and early 2000s, genetically modified (GMO) seeds were developed and became available to farmers (NIFA & USDA 2014). GMO traits gave high yielding hybrid seeds resistance against insects and herbicides and are purported to increase a seed's ability to reach yield potential. The ability to control weeds with herbicides and not just cultivation popularized no-tillage practices in the 1970s (NIFA & USDA 2014). Improved fertilizers and application techniques have also increased crop yields.

Machinery became more productive due to size increases which allow more ground to be covered with each pass. In the 1990s information technology, global positioning systems (GPS), and satellite technology began to be implemented in farming practices (NIFA & USDA 2014, Cengage Learning 2015). This allowed farmers to track

and map soil nutrients, acres planted, and yield results. More recently automatic steering was developed and has reduced producer fatigue, increased accuracy of row spacing, provided straighter rows, and centralized compaction, all adding to the productivity of land being cultivated (Cengage Learning 2015).

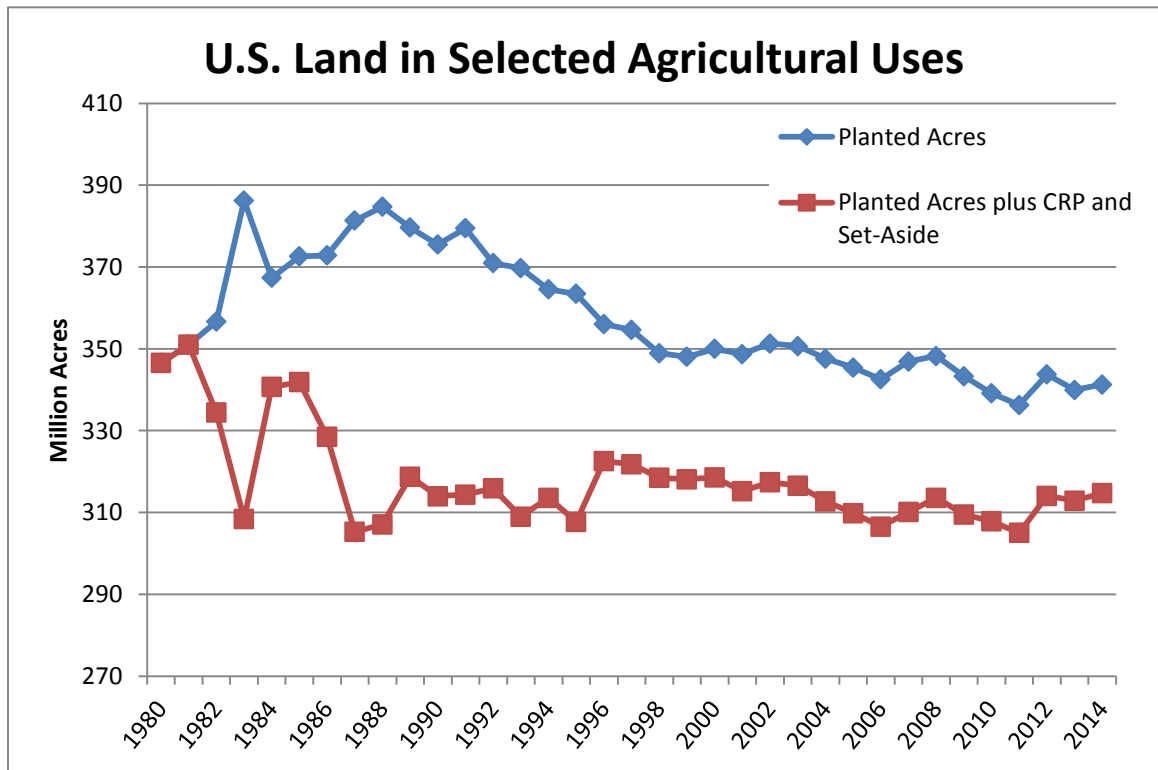
Increased prices coupled with institutional change and socioeconomic influences fostered a boom atmosphere in agriculture during the 1970s. In the early 1980s many farmers were caught between low prices and bullish debt leveraging resulting in a farm sector financial crisis (Barnett 2000). Supply increased with increases in productivity per acre and exports fell as the cost of U.S. goods sold overseas rose due to the strengthening of the U.S. dollar (Barnett 2000).

Set-aside and Conservation Reserve Program (CRP) government policies decrease the amount of land in crop production; the goal of set-aside was to control commodity supplies, and CRP is meant to conserve soil and reduce environmental effects of erosion (Cain and Lovejoy 2004). Set-aside programs began with the Agricultural Adjustment Act of 1933, and provided price supports to farmers that voluntarily took acres out of production (Cain and Lovejoy 2004). Set-aside programs continued to incentivize farmers to leave acres out of production until they were discontinued in the Federal Agriculture Improvement and Reform Act of 1996. The Food Security Act of 1985 established CRP as well as other conservation programs (Cain and Lovejoy 2004). CRP compensated farmers to take highly erodible land out of agriculture production for a ten-year period. Both programs have influenced decisions in the

farmland market, the acres in crop production, and the returns available to producers and landowners.

Figure 2 shows the historical number of U.S. acres planted for corn, soybeans, wheat, upland cotton, sorghum, barley, oats, rice, sunflower, peanuts, canola, and sugar beets, plus harvested area for sugarcane and hay (USDA National Agricultural Statistics Service (NASS) QuickStats). The top line includes these planted and harvested acres, as well as acres enrolled in CRP and set aside by pre-1996 annual farm programs. By either measure, it is evident that acres used for crop production have decreased since the 1980's.

Figure 2- U.S. Land in Selected Agricultural Uses

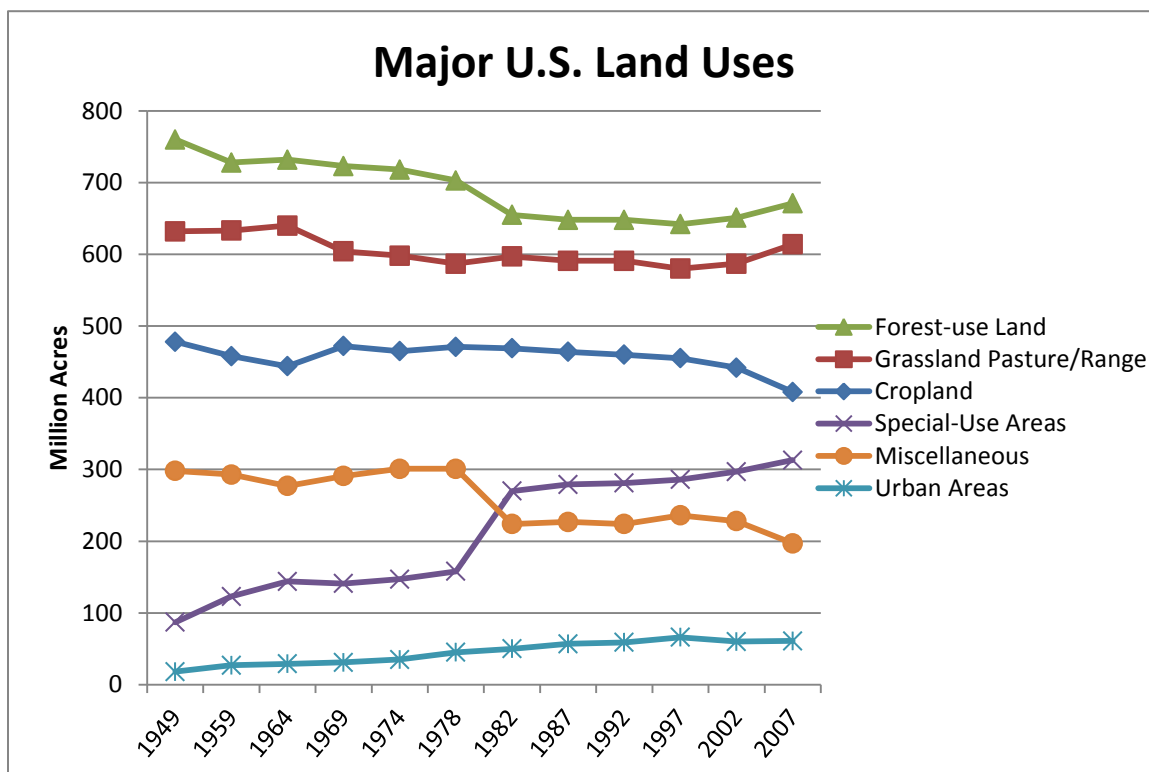


The 1949-2007 data in figure 3 and table 1 are from the 2011 USDA ERS report “Major Uses of Land in the United States, 2007”. The report includes data from the Census of Agriculture that is produced every 5 years, and from the USDA Forest Service, NASS, and the Census Bureau. It is cautioned that recent numbers are not comparable because use categories were reclassified and exchanges occurred between categories that could lead to incorrect conclusions about changes in land use patterns. Also, the cropland category includes idled acres that are not used in production because of government programs, adverse weather at planting, or the lack of economic incentives to plant. (Nickerson, Ebel, et al. 2011). The idled acres could be brought in and out of production without affecting the cropland acreage reported, so economic decisions could be hidden within the category.

Table 1- U.S. Land Use

Major U.S. Land Uses, Results from the Census of Agriculture Reported by USDA ERS												
Million Acres												
	1949	1959	1964	1969	1974	1978	1982	1987	1992	1997	2002	2007
Cropland	478	458	444	472	465	471	469	464	460	455	442	408
Grassland Pasture/ Range	632	633	640	604	598	587	597	591	591	580	587	614
Forest-use	760	728	732	723	718	703	655	648	648	642	651	671
Special-Use	87	123	144	141	147	158	270	279	281	286	297	313
Urban Areas	18	27	29	31	35	45	50	57	59	66	60	61
Miscellaneous	298	293	277	291	301	301	224	227	224	236	228	197
Total Land	2273	2271	2266	2264	2264	2264	2265	2265	2263	2263	2264	2264

Figure 3- U.S. Land Use



According to the USDA ERS land use report, cropland acres have fallen since 1982 and from 1949-2007 the major land use trend was a continual increase in special-use and urban areas (Nickerson, Ebel, et al. 2011). The special use category consists of rural transportation, rural parks and wilderness areas, defense/industrial, and farmsteads; the major increase within special use was for parks and wilderness areas (Nickerson, Ebel, et al. 2011). Data from the National Resources Inventory (NRI) was consulted because the recent censuses could not be compared. NRI confirmed that cropland did decrease, and revealed that since 1982 the largest flows into and out of cropland occurred between 2002 and 2007. Some acres entered into cropland while others exited; the net result was a loss of 10 million acres in the 5 year period. Of the

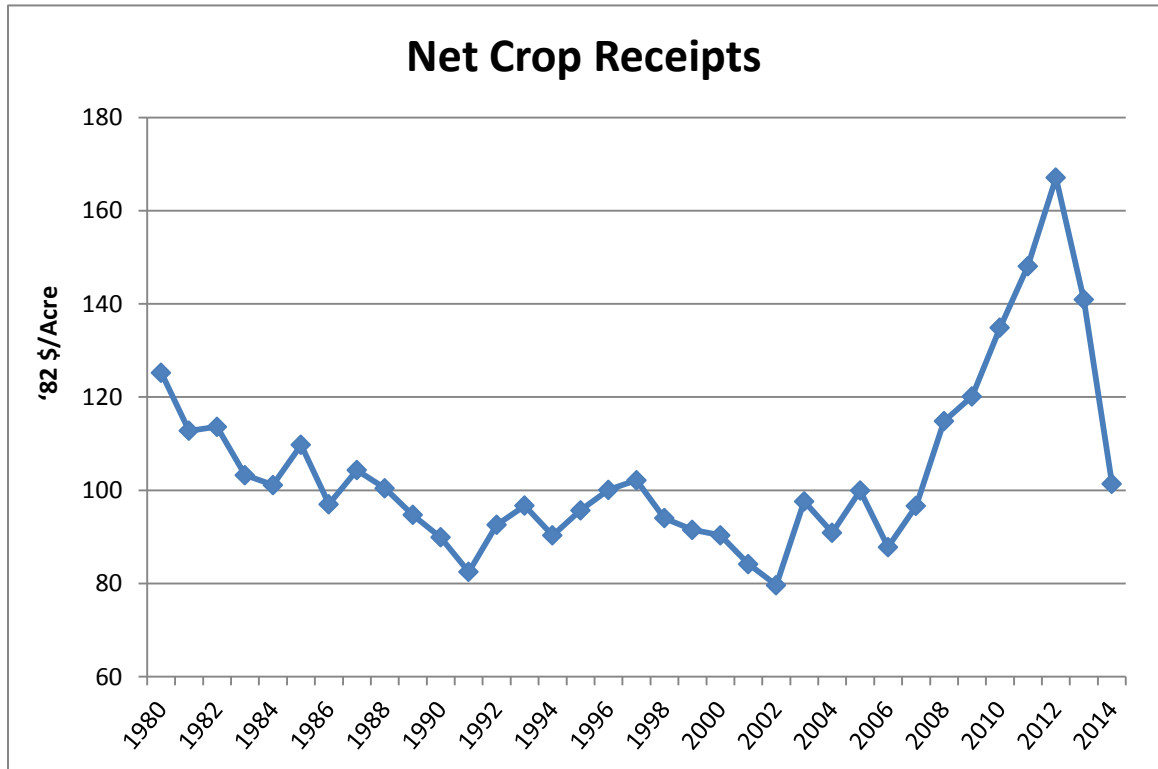
acres exiting cropland, 78% of them transitioned to pasture or rangeland use, a large portion of the rest went to forest use. Of the land entering cropland 85% had been in pasture or rangeland in 2002.

Landowners attempt to maximize returns, which can be influenced by commodity prices and by agricultural and bioenergy policies. Near urban areas land use is also affected by the demand to transition land-use to residential, commercial, and industrial development (Nickerson, Ebel, et al. 2011, Borchers, Ifft and Kuethe 2014). Land that is flat and good for farming is also desirable for urban use, but once land shifts to urban use it does not shift back to less intensive agricultural use (Nickerson, Ebel, et al. 2011).

The profitability of crop production generally increased between 2005 and 2012, as increased demand from China, the expansion of biofuel production, the 2012 drought, and other factors pushed crop prices higher. Production expenses for fertilizer, seeds and other inputs also increased, but not as fast as receipts (Morehart 2014). The USDA ERS “2015 Farm Sector Income Forecast” expects net cash income to decline for the second straight year in 2015, due primarily to reductions in crop prices caused in part by record corn and soybean yields in 2014 (Morehart 2015). Figure 4 shows historical net crop receipt data through 2014. This series was calculated by using farm income accounts reported by the USDA; it is the sum of crop receipts and government payments minus seed, fertilizer, chemical and other selected expenses. The decreasing receipts and increasing expenses shrink the profit margin in 2013 and 2014 and it is

argued that lower rental rates will need to be negotiated to secure a sustainable margin (Liddell 2014).

Figure 4- Net Crop Receipts

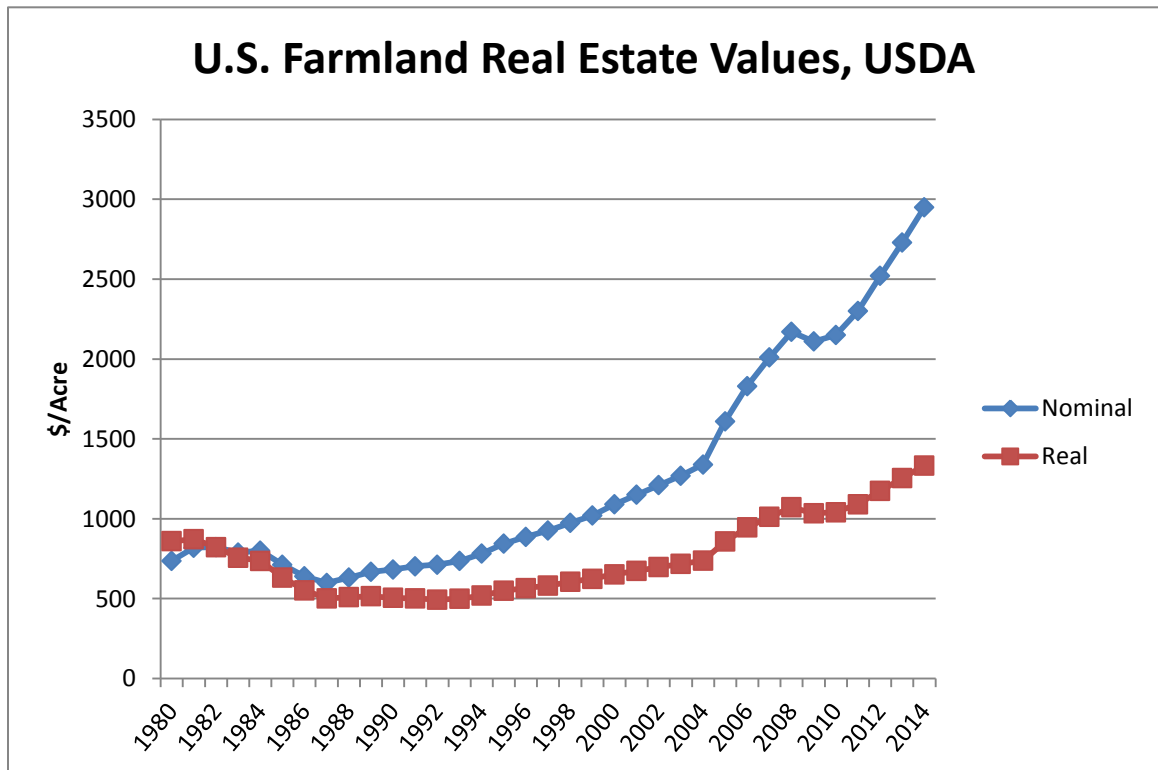


Interest rates influence farmland values because they are a fundamental determinant of the opportunity cost of capital and thus the capitalization rate. There is an opportunity cost of owning land because funds used to purchase it could be invested in a different asset. “Lower interest rates reflect a lower opportunity cost of capital, reducing the discount applied to future earnings received from farmland, and increasing the farmland valuation multiple” (Gloy, et al. 2011). Recent historically low interest rates have contributed to the growth in land value because they made debt cheaper

(Nickerson, Morehart, et al. 2012). The historical yield of AAA-rated corporate bonds (the discount rate used in this analysis) is in figure 17.

From 1987 to 2004 farmland values reported in USDA NASS QuickStats (figure 5) increased from \$599/acre to \$1,340/acre, an average annual growth rate of 4.9%. In 2005, farmland value increased by 20%, in response to record crop and livestock receipts and large government payments under the 2002 farm bill. During the Great Recession (2008-2009) there was a short period of decline in farmland value, but following economic recovery, values increased at pre-recession rates, reaching an average value of \$2,950/acre in 2014.

Figure 5- U.S. Farmland Real Estate Values



Recent increases in farmland value have been attributed to higher net crop receipts and low interest rates (Morehart 2014). Many crop prices in 2012 and early 2013 experienced record highs. In 2014, record crop production led to increased supplies which lowered prices, absent an increase in demand. Prices below the 2007-2012 average are projected to be the norm for the next few years as long as there are no weather issues that decrease production similar to the 2012 drought, and if there are no unexpected changes in foreign demand and U.S. exports (FAPRI 2015, Westcott and Hansen 2015).

Worry surrounded the recent increases in farmland values because of the boom and bust that had recently occurred in the residential land market, and the farmland value bubble that collapsed in the 1980s (Gloy, et al. 2011). Economists have been following the recent shifts in U.S. agriculture markets and had warned of a drop in land prices that has now been reported in some areas. The rapid growth in farmland values followed economic principles; since returns have now fallen, land values should also recede if these changes in realized returns affect expectations for the future. Land values could be at further risk if there are unanticipated increases in interest rates. This research seeks to estimate and quantify the effects economists have suggested.

According to the 2014 Iowa State University land value survey, farmland values in Iowa fell 8.9% in 2014; which was the largest decrease since 1986. Duffy (2015) cites similar surveys that reported decreases of 5.4% from September 2013 to March 2014 (Realtors Land Institute), 3.4% decrease from March 2014 to September 2014 (Realtors

Land Institute), and 4% decrease from October 2013 to October 2014 (The Federal Reserve Bank of Chicago). Though time periods covered are different between the opinion surveys the general trend is that farmland values in Iowa are decreasing as returns decrease (Duffy 2015). Iowa values are a good indicator of values across the Midwest because it is one of the main crop producing states.

The land market has other characteristics that include, but are not limited to, its immobility and thinness. Land is immobile, so market interactions are local and the nature of personal relationships between farmers and landowners influences the outcomes of individual transactions. Relationships and multiple year rent contracts may lead rental rates to react slowly to market shocks. Furthermore, land is a thin market, meaning a small portion of the total is sold in a given year. It is estimated, on average, that only 0.55 – 0.73% of land is sold annually (Sherrick and Barry 2003).

III. Economic Theory

The economic theories that are the basis for the model design in this thesis will be explained in this section. The assumption is made that land is bought and sold in a perfectly competitive market in which individuals do not influence the aggregate market and that the self-interested decisions of buyers and sellers come together to determine a market price. It can be argued that land is not a perfectly competitive market, but there are no large gains to be made from deviating from the perfect competition assumption

Derived demand is applied and is defined as the “Demand for a good that is derived from the production and sale of other goods” (Besanko and Braeutigam 2011, 30). In this model the demand is the willingness to pay for the land so that the farmer can sell the production at the end of the season. The farmer demands acres to plant in order to maximize profits in producing and selling a crop. The foundations of derived demand lie with Ricardian rents, which will be explained later. The law of demand states, *ceteris paribus*, that when the price of a good increases the quantity demanded for the good decreases, and if the price of a good decreases the quantity demanded for the good increases. For this reason we expect that when estimating a demand equation the price and quantity variables should have a negative relationship.

Landowners are the suppliers in the land market outlined by this thesis, and are assumed to make decisions based on maximizing profits. The amount of land available is finite but the amount allocated for uses can fluctuate depending on market variables.

The law of supply states, *ceteris paribus*, when the price of a good increases the quantity supplied for the good increases, and if the price of a good decreases the quantity supplied for the good decreases. For this reason we expect that the price and quantity variables will have a positive relationship when supply is estimated.

David Ricardo states that, "Rent is that portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soil" (Ricardo 1911, 33). He further says, "Corn is not high because rent is paid, but a rent is paid because corn is high; and it has been justly observed that no reduction would take place in the price of corn although landlords should forego the whole of their rent" (Ricardo 1911, 38). Things that are abundantly available like air or sunlight have no price, but land is limited in quantity and will eventually generate rent. His theory of rent states that farmers pay rent for the use of the soil, so that they can have the right to sell the product of the land. When prices of agricultural commodities increase, marginal land is brought into production, raising the rent of all of the land that had already been cultivated before because of its superior qualities. Explained another way, landlords begin to receive rent when the land they possess has higher productivity potential than that of a lesser quality land when each is used for the same purpose. Rent can only be as high as what is justified by crop receipts in excess of non-rent production costs, and land values can only be as high as what is justified by the expected future rents that can be secured for it (Ricardo 1911).

Continuing with Ricardo's theory, pastureland generally is the marginal use for cropland and that means it will be the next land brought into use for crop production

when net returns rise. If more marginal land is brought into cropland use the rental rate will increase for all of the other cropland that has already been cultivated. The marginal land will then incur cropland rents higher than previously earned pastureland rent. The difference between the rent for the last unit brought into production and the land already in cropland use should reflect the difference in the productivity potential of the land (Ricardo 1911).

Capitalization theory and the concept of the time value of money are applied in this thesis. Many people understand it intuitively: when given the choice of a sum of money today or the same sum of money a year from now we choose to receive the money today. This decision becomes harder when the sum received today is a different amount than what could be received in the future. To compare the two options an interest rate is used to discount the future value into a present value so that both are in time-equivalent terms. The discount rate represents the return that could be gained through alternative investments. This concept provides the equation for a perpetuity investment, which is an annuity (an investment that has a stream of payments over a period of time) that lasts forever (Besanko and Braeutigam 2011, 144-146). It is the present value of a perpetuity equation that Alston and Goodwin, Mishra, and Ortalo-Magne applied to the land market of which the stream of payments is rent received by the landlord. The next chapter will review the literature in greater detail.

IV. Literature Review

In this chapter, past methods of projecting farmland values will be summarized in chronological order. The cited articles were chosen to capture the main techniques used in practice as the scope of literature on this topic is very wide. Early methods by Tweeten and Martin and by Herdt and Cochrane involved supply and demand modeling. Alston and Goodwin, Mishra and Ortalo-Magne document present value formulas that apply a discount rate to expected future returns that can be received through land ownership. This thesis utilizes both of these approaches to provide a system that allows economic factors to be traced through the market and decision making process of farmers and landowners to be quantified.

Tweeten and Martin (1966) used ordinary, recursive, and auto regressive least squares to estimate their five-equation supply and demand model which determines land prices, the amount of land in farms, the amount of cropland, farm numbers, and farm transfers. The dependent variable, land price, is defined as the deflated price index of U.S. farm real estate including buildings. The land-in-farms, transfers, and farm numbers variables were expected to be negative. Government payments and pressure to increase farm size were identified as large sources for the variation in land price during the boom of the 1950s and early 1960s (Tweeten and Martin 1966). The estimated short and long run elasticity of land price with respect to Tweeten and Martin's chosen variables are listed in table 2.

Table 2-Land Price Elasticities, Tweeten and Martin

Land Price Elasticities, Tweeten and Martin		
With respect to	Short Run	Approximate Long Run
Land-in-Farms	-0.46	-1.84
Transfers	-0.73	-2.92
Farm Numbers	-0.134	-0.536
Net Farm Income	0.086	0.344

Herdt and Cochrane (1966) developed a simultaneous system of equations 2, 3, and 4. Parameters were estimated for equations 2 and 3 using two-stage least squares regression analysis. Price of farmland was defined as the average value per acre of land and buildings and quantity was defined as the number of farms. The price level, the ratio of prices received to prices paid, and technological change variables were included with three-year weighted-average lags to reflect the time it takes for land markets to adjust (Herdt and Cochrane 1966).

2

$$\text{Supply} = f(\text{Price}, \text{Interest Rate}, \text{Unemployment}, \text{Land in Farms})$$

3

$$\text{Demand} = f(\text{Price}, \text{Interest Rate}, \text{Productivity Index}, \text{Ratio of Price Received/Price Paid}, \text{Urban Land}, \text{General Price Level})$$

4

$$\text{Supply} = \text{Demand}$$

The purpose of their study was to show the impact technological advances in farming operations have on farmland values. Productivity was found to have the most influence on land prices (Herdt and Cochrane 1966). Perhaps due to multicollinearity problems, some coefficients did not have the expected signs (for example, higher interest rates were found to increase land prices), but it was concluded that income

gains from technological advancement (and increasing urban demand) inflate the price of land.

Klinefelter (1973) used a least-squares regression model to estimate the effects that inflation, net rents, government programs, technology, farm enlargement, farmland transfers, and capital gains have on farmland value. He proposed equation 5, in which V is the value of farmland and buildings per acre, P is the price deflator for gross national product, NR is net rents, which is a proxy for net returns to farmland, E (Cg) is expected capital gains, A is the average size of farm in acres, C is the three-year moving average corn yield, T is the number of voluntary transfers in farmland, and GP is the total amount of government payments per acre (Klinefelter 1973).

5

$$V=f(P, NR, E(Cg), A, C, T, GP)$$

The following expectations and hypothesis were made concerning the variable effects on farmland value in equation 5. "Due to the fixed nature and diminishing quantity of available farmland, coupled with increasing demand for alternative uses, it may be assumed that real value of farmland has not declined" (Klinefelter 1973, 27). Therefore, inflation (P) would have a positive effect on farmland values. Net returns would have a positive effect on farmland value because the larger the expected returns stream the higher the present value of land. Expected capital gains would also have a positive effect due to tax incentives of owning land as an investment instead of common stock when considering long-term capital gains, and because the growth value of the asset represents a large part of total value. (Klinefelter 1973).

Klinefelter applied the hypotheses from Heady and Tweeten, Tweeten, and Tolley, that farmland value gets bid up in the market as demand for farm enlargement (average farm size) increases. The desire for economies of scale increases the demand for farm enlargement as managerial and labor capabilities increase with new technologies. The corn yield variable is used as a proxy for technological advancement, which is expected to have a positive effect on farmland values when combined with benefits from government farm programs. Farmland transfers represent the supply of farmland in the market; when transfers decrease, the competition in the market increases, given the demand for farm enlargement and other use does not fall, and has a positive effect on farmland values. Government payments are hypothesized to be positively correlated with farmland values for two reasons, payments for diverting acres under previous farm programs created artificial scarcity of land, and because price supports increase value through increasing net returns. (Klinefelter 1973).

After getting unsatisfactory results from estimating the full model (equation 5), Klinefelter adopted the simplified equation 6 to reduce multicollinearity and obtain coefficients with signs that are suggested by economic theory. He recommends that future research include the rate of interest on borrowed capital as an explanatory variable. Results were that 97.3 % of the variation in land values can be explained by net rent, average farm size, the number of voluntary transfers of farmland, and expected capital gains (Klinefelter 1973). Elasticity results for the estimated equation 6 are in table 3.

$$V=f(NR, Cg, A, T)$$

Table 3- Farmland Value Elasticities, Klinefelter

Deflated Index of Farmland Value Elasticities, Klinefelter	
With respect to	Elasticity
Net Rent	0.0426
Capital Gain	0.0863
Average Farm Size	0.7432
Voluntary Farmland Transfers	-0.1333

In Pope, et al. (1979) the equations outlined by Reynolds and Timmons, Tweeten and Martin, and Herdt and Cochrane, were analyzed with new data to see if they were still credible. All of the previous models that were tested had issues of sign reversal. Pope, et al. chose Herdt and Cochrane's formula for further forecasting, but did not include lagged variables. The Herdt and Cochrane method was compared with the single equation model proposed by Klinefelter and a Box Jenkins time series forecast of land prices. It was concluded that time series performed the best, Klinefelter provided good results and was liked for its inclusion of selected predictors, and Herdt and Cochrane's model was deemed unreliable because of coefficients having inappropriate signs and not being statistically different than zero (Pope, et al. 1979).

Melichar (1979) studied farmland value using the asset-pricing theory (equation 7). V is the present value of the asset, g is the annual growth rate of the current return, d is the discount rate applied to future returns, and R is the present current return (Melichar 1979). He stresses that relating net farm income to land price is incorrect because an aggregate return is compared to a unit price, other productive assets are

ignored, and rental income to nonoperator landlords and interest paid on debt are excluded. Before comparing data the series used are deflated by the CPI. Melichar states that "...the value of an asset grows at the same rate as its return" (Melichar 1979, 1089). He finds that technological change, government programs, and increased demand led to growth in the current return to land and thus an increase in value.

7

$$V = ((1+g)/(d-g))R$$

Alston (1986) is cited by many peers for using the present value method to analyze farmland price and the conclusions he draws from it. His analysis focused on cash rents as a proxy for the income from owning land instead of a residual farm income value (Alston 1986). Alston used equation 8 to apply capitalization theory.

8

$$V_t = R_t / D_t$$

V is the present value of the price of land, R is the expected net rental income to land and D is the discount rate. The discount rate is adjusted using equation 9, where i is a nominal market interest rate, g is the nominal expected growth rate of land price, T_c is the constant rate of capital gains tax, c is a risk premium for land, and T_y is the constant flat rate of income tax (Alston 1986). Alston concluded that inflation does not have a large effect on land prices but real growth in net rental income does.

9

$$D_t = i_t - g_t(1 - T_c) / (1 - T_y) + c_t / (1 - T_y)$$

Burt (1986) analyzed farmland prices using a second-order rational distributed lag structural form on land rents with variables transformed to logarithms. “The annual percentage change in price can be interpreted as the sum of two components: (a) 13% of the percentage difference between an equilibrium land price consistent with current expected rent and land price in the previous year, and (b) 75% of the percentage change in land prices the previous year.” (Burt 1986, 25). “...rents are the underlying source of value, and there is little evidence that farmland prices are driven by the same kind of speculative forces as those for nonincome earning assets such as precious metals and stones” (Burt 1986, 25). Burt’s results implied that interest and inflation rates did not have a statistically significant influence on land prices.

Featherstone and Baker (1987) used vector auto regression to analyze the dynamic response of real farm asset values to changes in net returns and interest rates. They concluded that the farm asset market is prone to bubbles because of inherent overreactions when market shocks occur.

Goodwin, Mishra, and Ortalo-Magne (2003) summarized the current methods being used to analyze farmland value. They focused mostly on the present value method in an effort to identify the capitalization of government program payments into farmland values. Their critique pointed out errors in past research such as failure to address autocorrelation. Empirical analysis of farm-level data from 1998-2001 was used and through disaggregating programs by type they were able to state “...that policy does indeed affect land values and that different policies have very different effects on land

values” (Goodwin, Mishra and Ortalo-Magne 2003, 750). For example they argue that price supports have a larger effect on land values than disaster payments because price supports reduce uncertainty in the agricultural market.

Lence and Mishra (2003) analyzed the effect government program payments have on cash rents instead of land value, which had been the norm. This method is useful because cash rents and land value are closely related in many models (e.g., Alston). Panel data from Iowa farms were used, in which disaggregated government programs are put into per acre values. Though Lence and Mishra look particularly at cash rental rates they conclude, similar to Goodwin, Mishra, and Ortalo-Magne, that different programs result in different effects on land value.

Shaik, Helmers, and Atwood (2005) used a recursive model to estimate factors that affect farmland values. They were able to obtain partial elasticities of land values and therefore have estimates of the shares of farmland value that is generated by expected crop returns and farm program payments. In estimation they separated each farm bill and results show that elasticities are different for the payments received under each bill. A variable for risk (expected variability associated with crop receipts per acre) was included and had statistical significance. The average elasticity of land value from 1940-2002 was 0.71 with respect to crop returns and 0.27 for farm program payments (Shaik, Helmers and Atwood 2005). Empirical results indicated land values have a positive and significant relationship with expected real crop receipts and farm program payments.

Moss and Katchova (2005) review literature on farmland valuation, providing support for the need to continually develop better ways to model farmland value because past methods are constantly being rejected by empirical data. They address asset performance and find that the rate of return for farm assets is similar to nonfarm businesses, questioning the necessity of farm programs. Their review of literature did not find closure on the effect government programs have on farmland values (Moss and Katchova 2005).

Gutierrez, Erickson, and Westerlund (2007) test the popular present value model against panel data of 31 states from 1960-2000 with cointegration and unit root hypothesis testing. They reject the present value model when the discount rate is assumed to be constant but fail to reject it if level shifts in a panel of multiple time series is used. The present value model with a discount rate that can have structural breaks was validated and results showed that a one percent increase in cash rent increases farmland prices by the same amount (Gutierrez, Westerlund and Erickson 2007).

Shaik and Miljkovic (2010) used a vector autoregressive model with income capitalization to analyze farm real estate values, farm returns, farm program payments, and real interest rates. Program payments over short and long-run periods were examined. To account for endogeneity, they used a dynamic framework. They point out that other variables affect land values but the agricultural variables they chose to use

influence most of US farmland. To calculate present value the infinite-life capitalization equation 10 is used.

10

$$V = A / r$$

V is the present value of the asset; A is the annual return, which is comprised of two components: cash receipts and government payments; and r is the discount rate.

The real interest rate is most commonly used as the discount rate. It was concluded that farm programs have a positive indirect impact on farm real estate via farm returns and that the effect occurs in the short run because of impulse response and expectations that once a payment is received it will continue to be received in the future (Shaik and Miljkovic 2010).

Schnitkey and Sherrick (2011) addressed the speculation that a price bubble was occurring in the farmland market. For convenience they use the capitalization formula in equation 11.

11

$$\text{Capitalized Value} = \text{Rent} / \text{Interest Rate}$$

Assumptions are made that farmland has an infinite life, and cash rents and discount rates are constant (Schnitkey and Sherrick 2011). The interest rate used in estimation is the yield of 10 year constant maturity Treasury notes. Schnitkey and Sherrick find that capitalized values have been similar to farmland prices, leading to the conclusion that prices have been driven by economic determinants and a price bubble is not likely to be occurring. They outline scenarios to show how changes in rents and

interest rates could affect farmland values. Their model suggests that large reductions in land values could occur if interest rates rise from recent levels.

Duffy (2011) makes comments similar to other papers that interest rates and returns on other assets have been very low, and that has been a contributing factor in farmland values. "Other things equal, lower returns elsewhere in the economy increase the demand for farmland" (Duffy 2011). Even though farmland values have increased rapidly, they have been following fundamental economic factors, unlike the price increases of the 1980s, he argues. Duffy draws attention to the demographics of the people that own land now, and those who are buying. Land owners are continuing to age and the percentage of elderly owners continues to rise. As they age it is not expected that their land will go into the market for sale, instead it will be transferred privately. More investors and fund groups are purchasing land, but the majority of buyers are still farmers. Prices could be influenced by a change in the demographics of the actors in the farmland market.

Salois, Moss, and Erickson (2012) use a cross-entropy based information approach to determine if farm real estate value is more related to urban pressure (population) or farm returns (net value added). Cross-entropy measures how related the information contained in different distributions is. Results of cross-entropy measures show that nationally the distribution of farm real estate value relates more to the distribution of net value added than population. Over time these relationships have changed, also, when analysis breaks the U.S. into farming regions, land values in some

regions are more associated with population than with returns. These results indicate that including returns variables in farmland valuation is more important than including population variables, at least when considering the U.S. as an aggregate (Salois, Moss and Erickson 2012).

In recent research, Borchers, Ifft and Kuethe (2014) used a hedonic price model to conclude that nonagricultural variables influence farmland values. Nonagricultural variables that contribute to land value are: the potential income from converting farmland to residential or commercial use, recreational uses of farmland, energy production, and mineral extraction (Kuethe, Ifft and Dyson 2014). These nonagricultural variables may help explain why farmland values have not declined as much as returns have in recent years.

Baker, Boehlje, and Langemeier (2014) compare the farmland price to cash rent ratio to the price to earnings ratio of stocks. The beta (risk) of farmland as an investment is then estimated through the application of a capitalization formula. Results showed that farmland is a desirable investment, comparable to stocks, and that it adds little risk to a diversified portfolio. However, even though farmland is a good investment they caution now is not the time to buy given the historically high price to rent ratio (Baker, Boehlje and Langemeier 2014).

V. Model

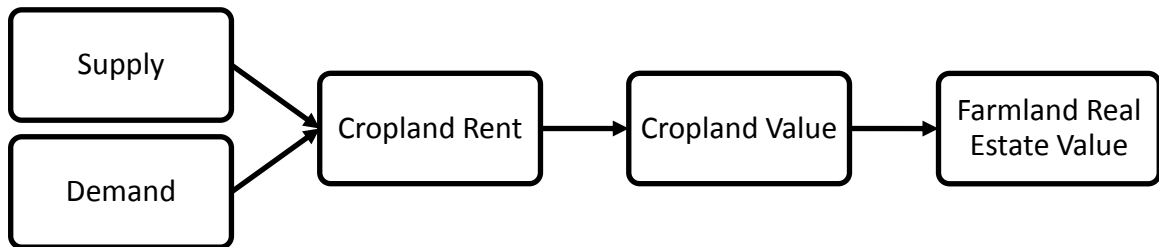
In this chapter the model utilized in this thesis is explained. The model modifies the supply and demand framework from Herdt and Cochrane, and Tweeten and Martin to project cropland rental rates in a deterministic model. Then the cropland rental rate is used in the present value framework from the research of Alston, Goodwin et al., and Schnitkey and Sherrick, to estimate cropland asset value. Lastly, a regression of farmland real estate value and cropland asset value is estimated to provide decision makers with a projected measure of farm sector health.

Figure 6 shows a diagram of the system used in this model to project farmland rental rates and asset values. Equations 12, 13, and 14 represent the deterministic model for the demand and supply. A deterministic model is one that provides a single numerical result in an error free environment; in contrast a stochastic model would include the possibility of error when describing a relationship between variables. Price will be determined when the quantity supplied and the quantity demanded reach equilibrium, solving these three equations estimates the equilibrium cropland rent price. Equation 14 is an estimation of cropland asset value using projected rent in the present value formula. Equation 15 estimates farmland real estate value using the cropland asset value.

Herdt and Cochrane, and Tweeten and Martin focused on land value as the market-clearing price, but this model focuses on the rent (price) paid to use land for crop production. The quantity variable in this model is crop acres; previous researchers

used land-in-farms, farm transfers, and farm numbers. The analysis is focused on the market decision to use land for crop production and not the decision to own land, which is addressed by the present value formula.

Figure 6- Model System Diagram



12

$$\text{Inverse Demand: Cropland Rent} = f(\text{Crop Acres, Net Crop Receipts})$$

13

$$\text{Supply: Crop Acres} = f(\text{Cropland Rent/Pastureland Rent, Population, Lag Dependent})$$

14

$$\text{Demand} = \text{Supply}$$

15

$$\text{Cropland Asset Value} = f(\text{Cropland Rent/Interest Rate})$$

16

$$\text{Farmland Real Estate Value} = f(\text{Cropland Value, Lag Dependent})$$

Variable Explanations

Values and data used are from the 2015 FAPRI Baseline Briefing Book, FAPRI data files, IHS Global Insight, and USDA. Estimated equations include yearly data from 1991-2014 for equations 12, 13, and 14 and 1997-2014 for equations 15 and 16. Exogenous variables are net crop receipts, pastureland rent, interest rate, and population.

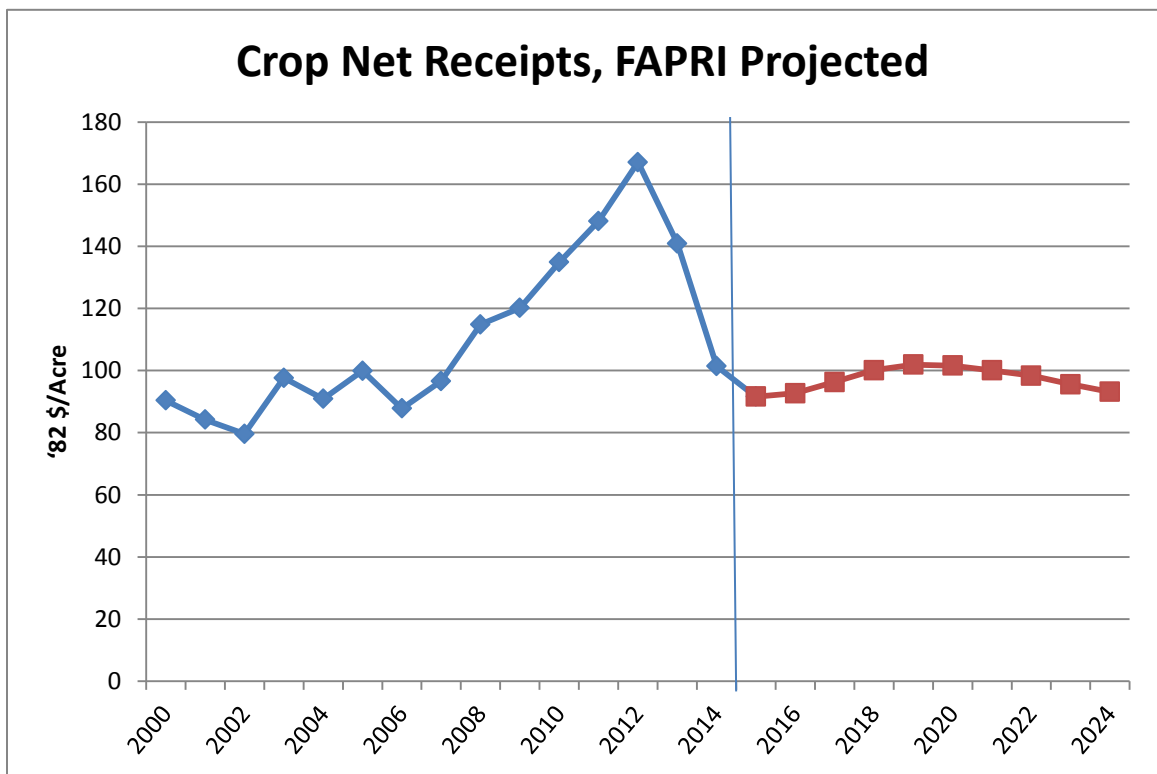
Endogenous variables are cropland rent, crop acres, cropland value, and farmland real estate value. Exogenous variables are ones that have known values outside of the system and endogenous variables have values that are determined by the system. Projected values of exogenous variables are from IHS Global Insight and the 2015 FAPRI baseline. Before estimation of equations 12 and 13, prices are put in real terms using a GDP deflator (base year 1982 = 100).

The crop acres variable (planted acres plus CRP and set-aside from figure 2 in chapter 2) behaves as the quantity in this model and is the sum of acres planted for corn, soybeans, wheat, upland cotton, sorghum, barley, oats, rice, sunflower, peanuts, canola, and sugar beets, plus harvested area for sugarcane and hay, acres enrolled in CRP, and annual acres idled by pre-1996 government farm programs reported by the USDA. Acres double-cropped to soybeans and another crop are subtracted from the total so that physical acres are not double-counted.

The net crop receipts variable (figure 7) is a per-acre moving average of values for calendar years $t-1$ to $t-5$. It is calculated from data reported in USDA farm income accounts by adding receipts from all crop production and all government payments and subtracting seed, fertilizer, and pesticide expense, and a portion of other farm sector operating expenses. The other operating expenses are calculated as 50% of the sum of repair and maintenance, contract and hired labor, machine hire and custom work, marketing, storage, and transportation, and miscellaneous operating expenses plus 70% of the fuel expense reported on the farm production expense sheet. USDA's net farm

income estimates include receipts from sale of both livestock and crop commodities and many past studies used this measure to estimate farmland value. The intention in this thesis is to reflect costs specific to crop production and exclude those associated with livestock production. Similar to Melichar, the focus is on returns to the specific asset to avoid aggregate measures that do not correspond with the asset being analyzed.

Figure 7- Crop Net Receipts, FAPRI Projected



Sector-level receipt and expense data can be found in USDA NASS QuickStats; to express the variable in dollars per acre, sector-level data are divided by the crop acres variable. USDA farm income accounts do not report separate estimates of crop insurance indemnity payments (they are included in a category labeled “farm-related income” that also includes income sources not likely to affect cropland values) so they

have not been included in this thesis. Further analysis could use indemnity data from USDA's Risk Management Agency to provide a more complete picture of crop producer income. Also, government payments are not disaggregated in this model even though literature has shown that different program types have different effects on land values. Further research could apply this model with disaggregated programs but estimation methods may need to be different to address multicollinearity and other issues that could result from expanding the number of independent variables.

Dollar per acre cash rent has been reported by the USDA since 1997 and is obtained through the cash rents survey that runs from February to July with results posted in August (USDA NASS 2011). The survey asks a sample of producers how many acres they rent and the \$/acre rental rate or total rent paid. In order to increase the number of observations, values were imputed back to 1991 using a trend and reported values from South Dakota that were highly correlated with the national series from 1997 to 2014.

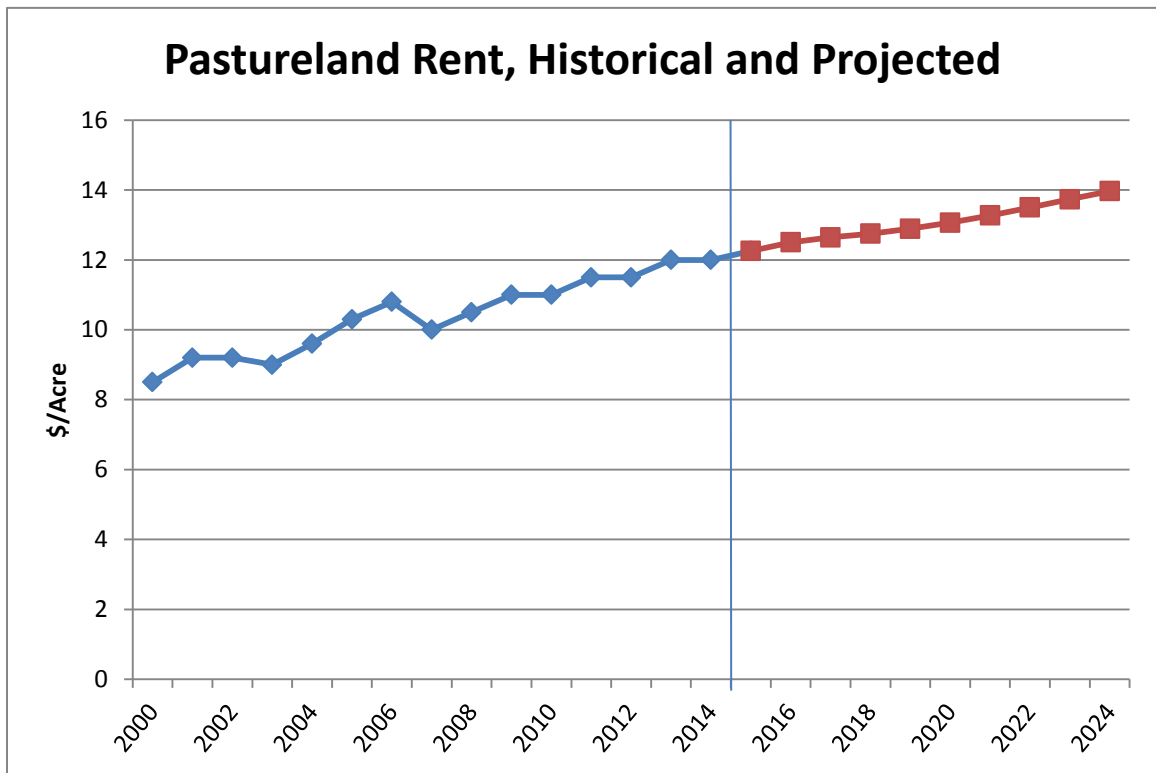
Pastureland rental rate data are reported in USDA NASS QuickStats from the cash rents survey. An OLS regression was used to increase the number of observations and to project the data into the future. A simple trend and lagged cow calf net returns reported by FAPRI were used to estimate pastureland rent. Results in table 4 indicate that pastureland rent is increasing by 0.221 dollars every year and that cow calf returns are not statistically significant. However, cow-calf returns are kept in the equation because of their economic significance and the coefficient has the expected positive

sign. The two variables captured roughly 94% of the variance of pastureland rent, and generate projections of continued slow increases in pastureland rental rates (figure 8). This estimation was not the focus of the thesis, so other research could be done to improve the projection of pastureland rent, perhaps using an approach analogous to that used here to determine cropland rental rates.

Table 4- Pastureland Rent Regression Results

Pastureland Rent		
R Square: 0.938		
Adjusted R Square: 0.929		
	Coefficient	P-Value
Intercept	8.168	3.44E-17
Trend	0.221	1.18E-09
Cow-Calf Net Returns	0.002	0.362

Figure 8- Pastureland Rent



The present value formula used in cropland value estimation, rent/interest rate, was identified in the literature review by Alston, Lence and Mishra, Shaik and Miljkovic, and Schnitkey and Sherrick. In this model the variables used are cropland rental rate and the seasonally averaged annual yield for AAA-rated corporate bonds (figure 17). The 10 year U.S. Treasury note and Federal Funds rate series were also tested for use but corporate bonds were selected because they had more statistical significance in estimation. In the scenarios chapter alternative interest rate projections will be tested to compare the effects they have on cropland asset value.

Historical cropland asset values are reported in USDA NASS QuickStats and are from the USDA NASS June area survey and estimates national average value based on operator's opinions of land value and percent change in value from the previous year, and land use information. Cropland asset value is defined by the USDA NASS as the value of land used to grow crops, vegetables or land harvested for hay and land that switches back and forth between cropland and pasture should also be valued as cropland (USDA NASS 2009). The crop area variable also includes idle cropland and cropland enrolled in government conservation programs, as this is land that could easily be used for crop production were it not for government rules. The crop area variable in the model captures most of this land, with the exception of the small amount of land used for vegetables and some minor crops. The data is reported in August and is listed as cropland asset value in USDA NASS QuickStats.

Farmland real estate value data is also estimated using information gathered by the annual USDA NASS June area survey. Farm real estate value is defined by the USDA NASS as the value at which all land and buildings used for agriculture production including dwellings, could be sold under current market conditions, if allowed to remain on the market for a reasonable amount of time (USDA NASS 2009). It includes both cropland and pasture and range land, although cropland would account for most of the total value. This series is listed as "agriculture land asset value including buildings" in USDA NASS QuickStats. Real estate value is included in this thesis because it is widely reported as an indicator of farm sector health due to its influence on farm equity.

January 2015 IHS Global Insight forecasts for macroeconomic variables have U.S. and global economies growing moderately over the next 10 years. The yield of corporate AAA-rated bonds is projected by IHS Global Insight to increase to 6% by 2018 and remain at that level for the rest of the projection period. The FAPRI projections include anticipated effects of the Agricultural Act of 2014 but there is still a lot of uncertainty surrounding the new farm bill. Future market returns and government payments are, of course, uncertain, and the analysis is forced to rely on projections that may change as more information becomes available.

Demand for Cropland

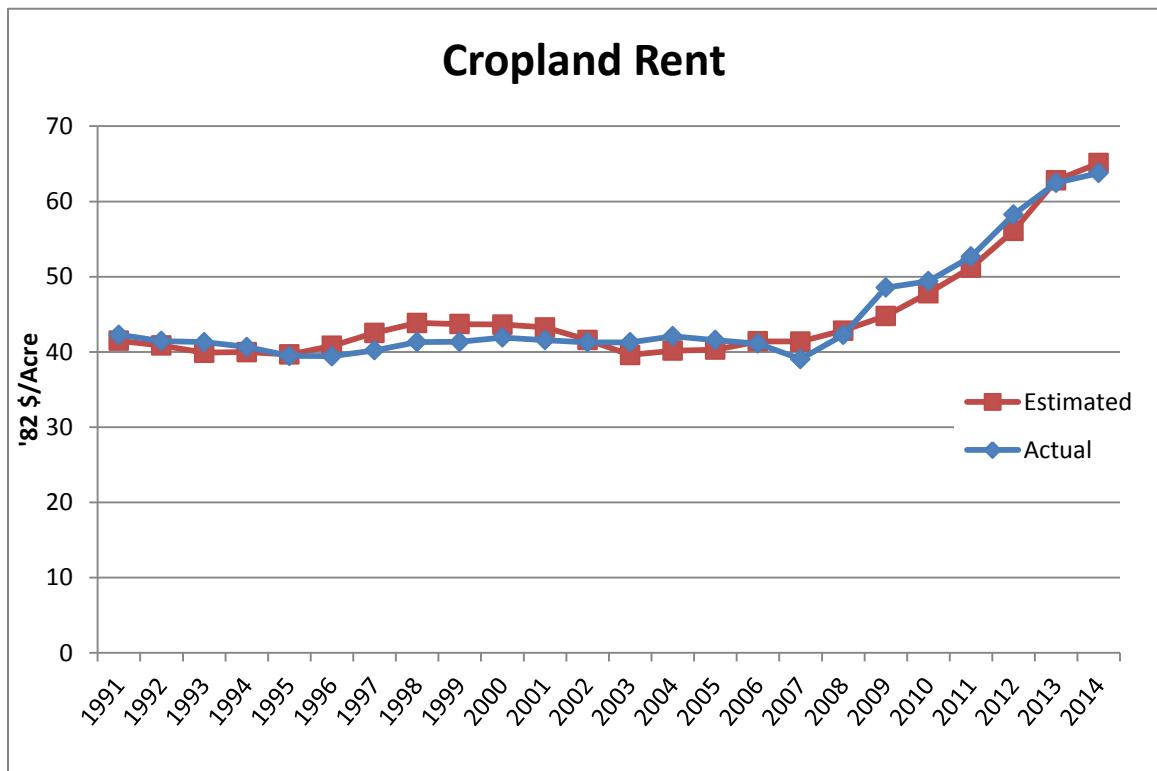
Most demand functions are solved for quantity demanded as a function of price. In this model an inverse demand equation is used so that price is a function of quantity. The equation is normalized with respect to rent; because price and quantity are

determined by demand and supply it does not matter whether the equation is defined with respect to rent (price), or crop acres (quantity) (Maddala 2001). It is hypothesized that crop acres will have a negative coefficient and net crop receipts will have a positive one so that the equation obeys the law of demand.

Table 5- Demand (Cropland Rent) Regression Results

Demand, Dependent Variable= Cropland Rent (1991-2014)			
R Square: 0.944			
Adjusted R Square: 0.939			
Durbin-Watson: 0.77			
	Coefficient	P-Value	Elasticity
Intercept	28.335	0.066	
Crop Acres	-0.082	0.041	-0.644
Net Crop Receipts	0.455	2.92E-13	1.011

Figure 9- Cropland Rent, Actual vs. Estimated



The OLS regression results for the inverse demand equation are in table 5 and the comparison of actual historical rent to estimated rent is in figure 9. The R^2 for regression is 0.944 indicating that 94.4% of the variance in cropland rent is captured by the crop acres and net crop receipts variables. Results were strongly conclusive, $p < 0.001$, that the coefficient is significantly different than zero, and that as hypothesized, crop receipts have a positive effect on rent. Increasing crop acres has a negative effect on rent, obeying the law of demand. "The p-value is the smallest significance level at which the null hypothesis can be rejected" (Stock and Watson 2011, 768). The null hypothesis is that the coefficient is zero, so in this estimation the variable coefficients are statistically different from zero at the 95% level or greater.

The Durbin-Watson d statistic ranges from 0-4, a value near 2 indicates non-autocorrelation while values that fall between 0 and 2 indicate positive autocorrelation and values between 2 and 4 indicate negative. Autocorrelation is a general feature of time series data because variables are correlated with their own lagged value; this can lead regression estimation to report misleading hypothesis tests and confidence intervals (Stock and Watson 2011). "...low Durbin-Watson statistics should spur us to ask if we have omitted any important variables whose omission might be biasing our estimates" (Murray 2006, 624). The demand equation has a d statistic of 0.77, indicating that it suffers positive autocorellation.

The elasticity result for rent and receipts in table 5 is almost exactly equal to 1. A 1% increase in net crop receipts would result in an almost exactly equivalent percentage

increase in cropland rent. When the estimated demand equation is manually inverted crop acres becomes the dependent variable and the implied elasticities for cropland rent and net crop receipts (-1.55 and 1.57, respectively) are almost equal in magnitude and opposite. This provides evidence that farmers are willing to increase the rent they pay as long as net crop receipts also increase. Since government payments are part of net crop receipts, an additional dollar of government payments would result, by construction, in farmers being willing to increase the rent they pay to landowners by the same as a dollar in additional crop receipts or a dollar less in production expenses.

The crop acres variable obeys the law of diminishing marginal returns, as the quantity of land (input) increases with other inputs such as capital and machinery held constant (*ceteris paribus*), a point will be reached where the marginal product decreases (Besanko and Braeutigam 2011). Economies of scale can be achieved in farming, but moments will occur when farmers have to expand machinery capabilities and hired workers in order to profitably manage the land they have chosen to rent. If production exists in the area of decreasing marginal returns each added acre provides less return than the one before and eventually increasing crop acres would incur a cost that is not offset by revenues. At such a point no one would rationally want to rent additional land.

Supply of Cropland

The supply equation was estimated with crop acres as the dependent variable and the ratio of cropland to pastureland rent (C/P), population, and lagged (t-1) crop acres as independent variables. The C/P ratio is used to capture the margin discussed by

Ricardo; if a given piece of marginal land can earn higher rent as cropland than as pastureland, it will be used as cropland. Assuming a distribution around mean values, an increase in the average cropland rental rate relative to the average pastureland rental rate should increase the number of marginal acres where cropland rent exceeds pastureland rent. It is hypothesized that the coefficient for the C/P variable will be positive, the population variable will be negative, and the lag variable will be positive and less than 1. The lag coefficient must be less than one so that long-run responses are finite.

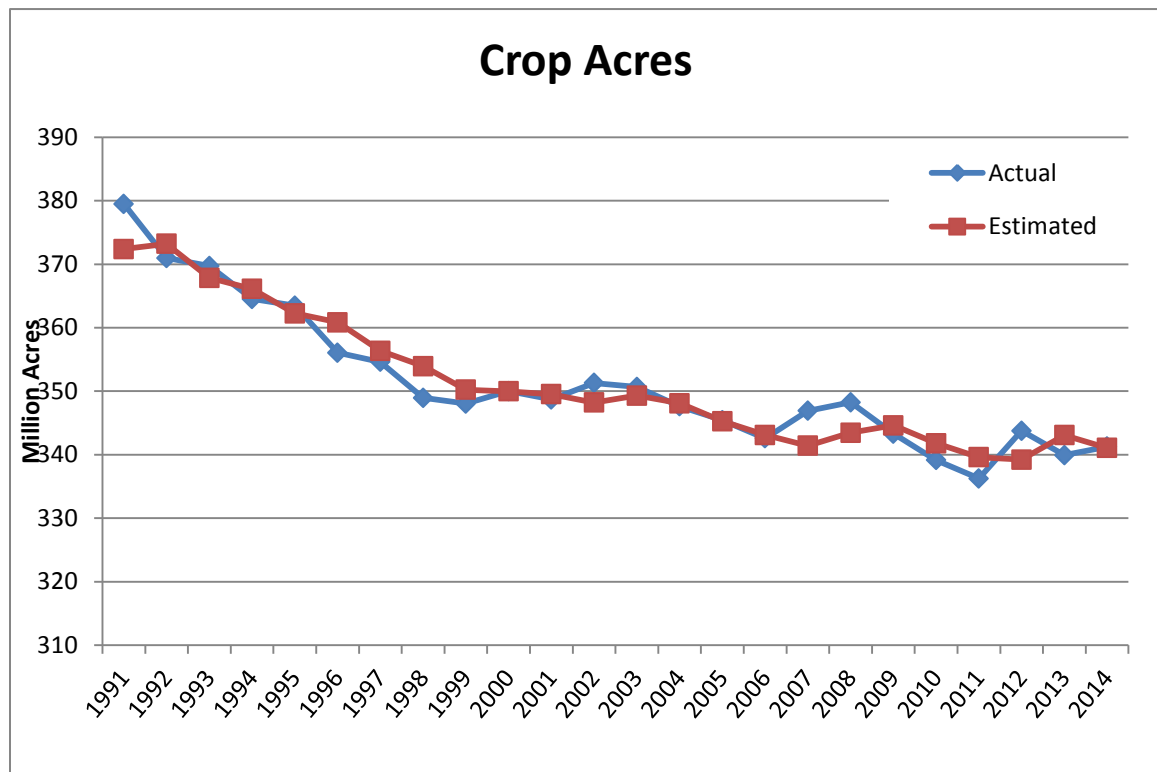
Table 6- Supply (Crop Acres) Regression Results

Supply, Dependent Variable= Crop Acres (1991-2014)				
R Square: 0.916				
Adjusted R Square: 0.903				
Durbin-Watson: 2.30				
	Coefficient	P-Value	Elasticity	
			Short Run	Long Run
Intercept	234.193	0.023		
C/P	1.400	0.107	0.034	0.071
Population	-0.263	0.044	-0.216	-0.445
Lag Dependent	0.513	0.012	0.515	

The OLS regression results for the supply equation are in table 6 and the comparison of historical crop acres to the estimated acres is in figure 10. The R^2 is 0.916 so 91.6% of the variation in the crop acres variable is captured by the selected variables. From figure 10 it can be seen that model error in 2007 and 2008 is high. The Durbin-Watson statistic is 2.3, but because the equation includes a lagged dependent variable, the d statistic is not a reliable indicator of autocorellation. Instead the h statistic should be calculated to be more conclusive. The C/P variable narrowly misses statistical

significance at the $p < 0.10$ level, but it does mind the law of supply; price has a positive effect on quantity supplied. Because it is a fundamental economic variable, it is kept in the equation. The population and lag variables are statistically significant at the $p < 0.05$ level. The coefficient on the lagged dependent variable can be interpreted to mean that half (0.5) of the quantity supplied will be determined by the quantity from the previous year, and that long-run response will be approximately double what it would be in the first year.

Figure 10- Crop Acres, Actual vs. Estimated



At the margin a decision is made whether the land should be used as pasture or for crop production. An explanation of the coefficient for the C/P variable is that as cropland rent increases, *ceteris paribus*, acres supplied for crop production will increase,

consistent with an upward-sloping supply curve. Alternatively if pastureland rent increases, *ceteris paribus*, the ratio of C/P will be reduced, and this will decrease the acres supplied for cropland and increase the acres supplied for pasture.

The population coefficient shows that as population increases, fewer acres are being used for crop production. As population increases there is more demand to use farmland for housing, recreation, and industry, effectively reducing the land in crop production. Because population increases steadily over time, it is strongly correlated with other variables with an underlying trend. Therefore, the coefficient on this variable may be capturing the effects of other omitted variables.

Supply = Demand

Using cropland rent as the equilibrator, equation 14 is used to set crop acres supplied and crop acres demanded equal to each other to calculate a future baseline for rent. Figure 11 compares historical cropland rent with the baseline, and shows values in nominal dollars per acre. The baseline is plausible because the projection of the net crop receipts variable decreases in 2015 from the record highs experienced between 2011 and 2013 and then increases slowly moving forward. With receipts being a 5 year trailing average in the model, the low of 2015 will bring rent down for the next few years before the assumed modest increase in net receipts causes rental rates to increase after 2020.

Figure 11- U.S. Cropland Rental Rate Baseline

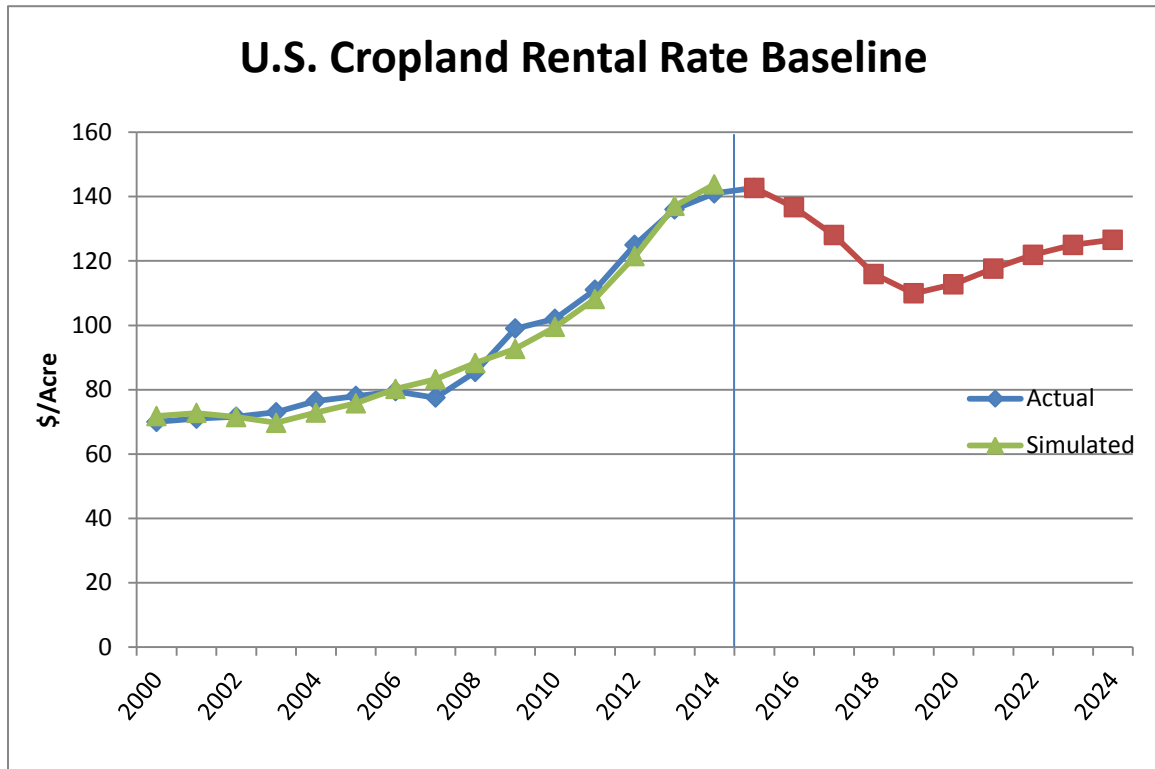
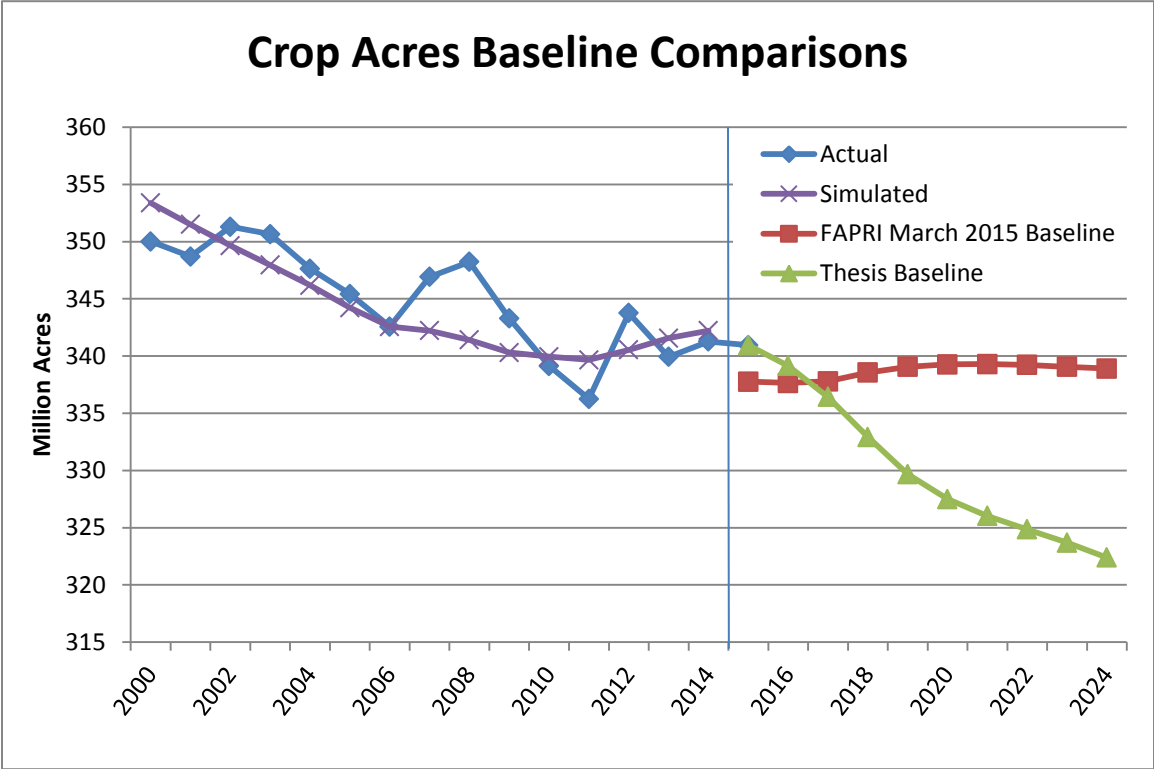


Figure 12 shows a comparison of historical crop acres to the projection generated by the supply and demand model and the 2015 FAPRI baseline projections. The crop acres projections for this thesis show a faster decline in acreage over the projection period than the 2015 FAPRI Baseline. This can be attributed to a strong negative effect population has in the estimated supply equation, as well as the projected decline in net crop receipts and rental rates. Other variables could be considered to replace or augment population in the equation, but adding more variables could just increase multicollinearity concerns. Crop acres have not been this low in decades but the decline is consistent with projected weak net crop receipts and a rising population.

Figure 12- U.S. Crop Acres Baseline, FAPRI vs. Thesis



Cropland Value

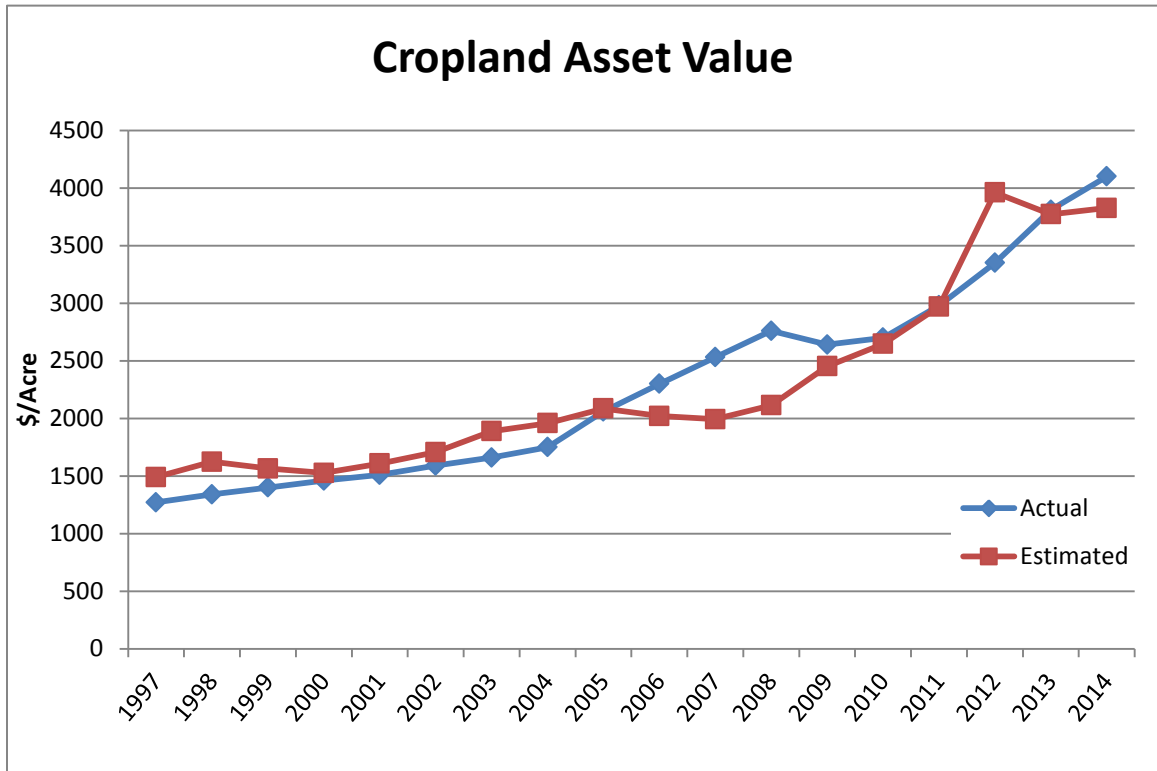
The present value method outlined by Alston and others is used in this system of equations to project the cropland asset value using the rent that is projected from the supply and demand model. The cropland rent value is the expected return of owning cropland and is discounted using the interest rate to provide the current value of the asset given the expected returns. As mentioned by Gloy et al. the interest rate is the opportunity cost because it is the return of the next best asset that could be invested in besides farmland. Nominal values were used in this estimation, and the implicit simplifying assumption is that market participants expect future rents to be constant in nominal terms. The assumptions made by Schnitkey and Sherrick that land has an

infinite life, and that nominal cash rents and discount rates are constant are applied in this model. Further research could examine the implications of alternative assumptions about future rental rates.

Table 7- Cropland Asset Value Regression Results

Cropland Asset Value (1997-2014)			
R Square: 0.881			
Adjusted R Square: 0.873			
Durbin-Watson: 0.89			
	Coefficient	P-Value	Elasticity
Intercept	626.675	0.002	
Rent/AAA	0.979	8.5E-09	0.726

Figure 13- Cropland Asset Value, Actual vs. Estimated

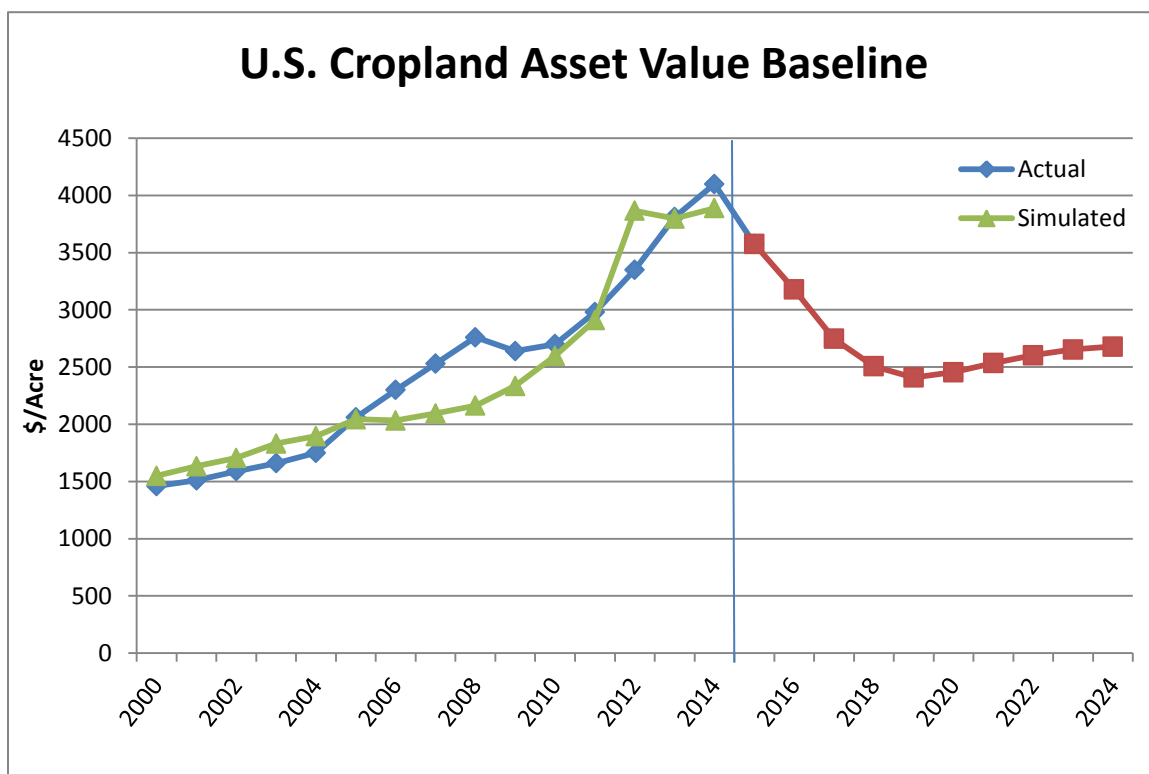


The OLS regression results for the cropland asset value equation are in table 7 and the comparison of actual historical values to model estimates is in figure 13. The R²

of 0.881 implies that 88% of the variance in the realized cropland asset value can be explained by the estimated present value. The Durbin-Watson d statistic is 0.89, indicating the asset value equation suffers autocorellation.

The results of using the estimated equation results (table 7) with the projected rent values from the deterministic model are in figure 14. The projected rent values are in figure 11, the projected interest rate from IHS Global Insight increases from 4.3% in 2014 to 6% in 2018 (figure 17). Increasing rent will have a positive effect on asset values and increasing the interest rate will have a negative effect. A lag dependent variable was attempted in this equation but was dropped because it had a coefficient of 0.9 which was considered too large, as it would have suggested a very slow adjustment period. Omitting the lagged variable effectively assumes a coefficient of 0. Further research could consider the question of whether land values or rental rates adjust more quickly to changes in returns. Without a lagged dependent variable in this equation, the model assumes that the two will adjust at the same speed; if a lagged dependent variable were included with a value between zero and one, it would imply that land values adjust more slowly to changes in returns than do rental rates.

Figure 14- U.S. Cropland Asset Value Baseline



Farmland Real Estate Value

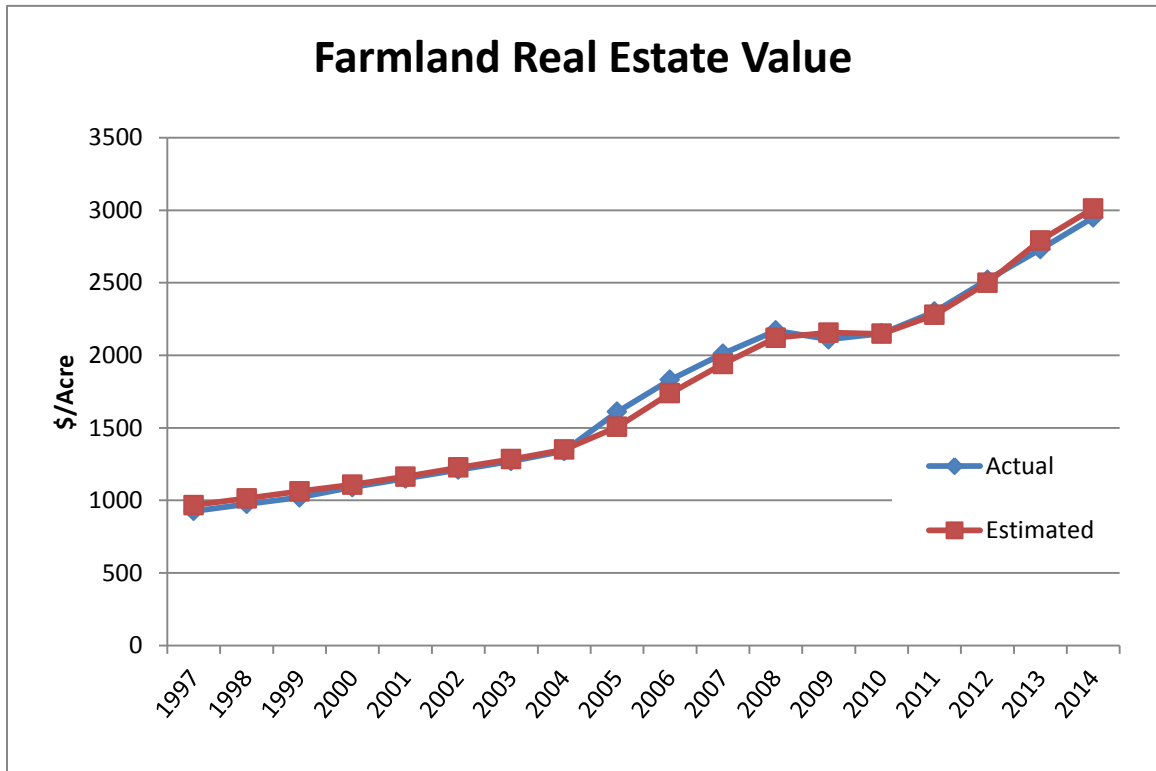
Using a simple linkage equation, the relationship between farmland real estate values and cropland value is estimated and the projected values in figure 14 are used to project real estate value. Regression results for the farmland real estate equation are in table 8 and a comparison of estimated and actual values is shown in figure 15. From the results it can be concluded that 99% of the variance in farmland real estate value can be explained by cropland asset value and the lag of farmland real estate value, and the estimated values are very similar to historical ones. These results were expected because the majority of farmland is used for crop production and the two series have a strong correlation. The Durbin-Watson statistic suggests autocorrelation, however

because there is a lag dependent variable the h statistic should be used to be more conclusive. Note that the estimated equation suggests that the long-term elasticity of farmland real estate values with respect to cropland values is almost exactly equal to one.

Table 8- Farmland Real Estate Value Regression Results

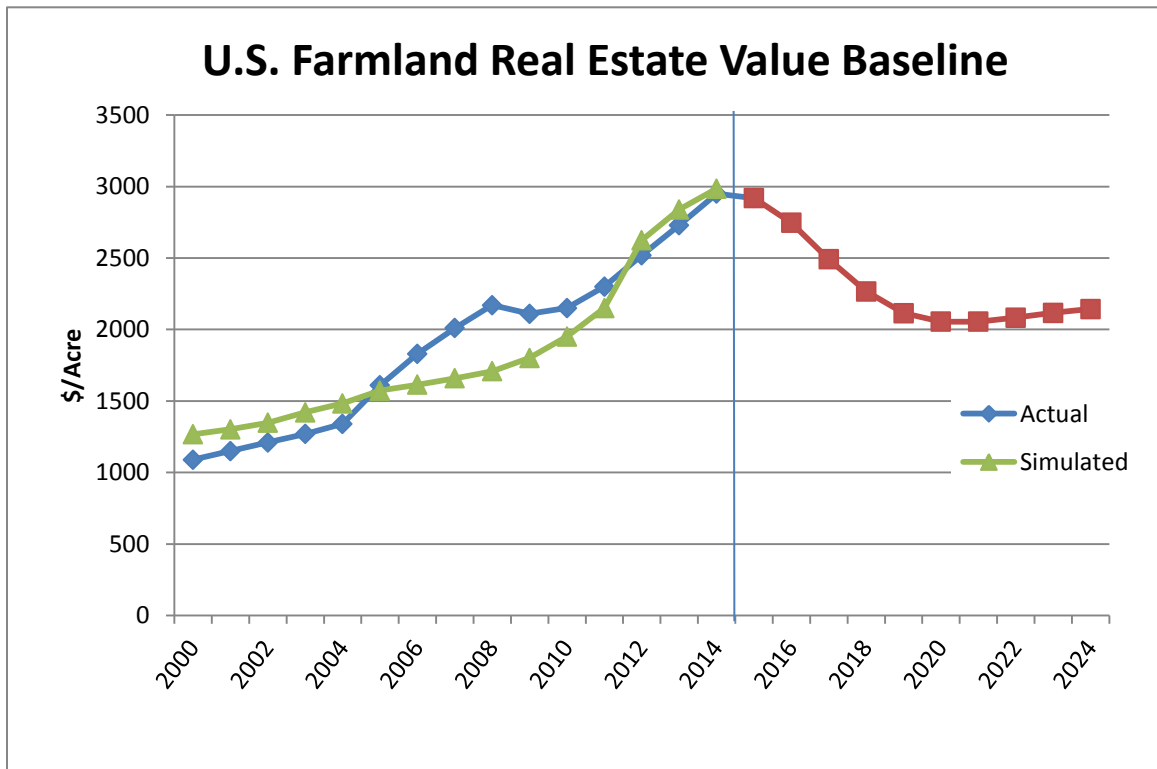
Farmland Real Estate Value (1998-2014)				
R Square: 0.994				
Adjusted R Square: 0.993				
Durbin-Watson: 0.79				
	Coefficient	P-Value	Elasticity	
			Short Run	Long Run
Intercept	18.111	0.635		
Cropland Value	0.391	2.22E-04	0.514	0.980
Lag Dependent	0.509	0.001	0.475	

Figure 15- Farmland Real Estate Value, Actual vs. Estimated



The projection of farmland real estate value created by this model is shown in figure 16. It is similar to the trajectory projected by the other equations in this system. Farmland real estate is expected to fall until 2020 at which point increases are seen in net crop receipts, and thus in the cropland rental rate and asset value. A 30% decrease in value is projected from the peak in 2014 of \$2950/acre to the trough in 2020 of \$2055/acre. The decrease is quite significant, and although these results have not been realized in the market, they may still occur. If interest rates remain at historically low levels longer than projected by IHS Global Insight, then this decrease will not be as drastic.

Figure 16- U.S. Farmland Real Estate Value Baseline



As with any market, black swan events like unexpected demand shifts due to foreign policy change cannot be foreseen. Decisions made today that depend on future outcomes must be based on the best estimates that can be made for the future; it was the goal of this thesis to provide such estimates. The outcomes generated in this thesis will not be realized, but the trends and overall story that the data tell is consistent with the assumed future crop receipts and interest rates.

VI. System Fit

To test how efficient the system is we compared estimation of the historical data with the actual values. The mean absolute percentage error (MAPE) was calculated for the endogenous variables to test errors in the system beyond the R-squared measure within the regressions. MAPE was calculated using equation 17 the output from the model equations (M) was compared to the historical values (H) to test how well the model replicates historical data.

17

$$MAPE=100/n(\sum(|Mt-Ht|/Ht))$$

The MAPE results (table 9) indicate that the system closely captures what has happened in the past, and much of the variability in farmland real estate value. The model estimates crop acres and cropland rental rate better than cropland asset value and farmland real estate value. This is not surprising given the respective R-squared of the equations. In this system the equations build on each other as diagramed in figure 6, therefore, cropland asset value estimation includes error from crop acres and cropland rent. Likewise, the error of farmland real estate value includes the error of cropland asset value. Techniques used by Gutierrez, Erickson, and Westerlund could be employed to identify structural breaks in the present value formula and improve model performance. The projections are not a perfect indication of what will happen in the future, but the model does include market fundamentals that have captured variance in the past that should still be relevant in the future.

Table 9- Mean Absolute Percentage Errors

MAPE for Endogenous Variables (1997-2014)				
	Crop Acres	Cropland Rent	Cropland Asset Value	Farmland Real Estate Value
MAPE	0.85%	3.32%	10.55%	12.25%

VII. Scenarios

This chapter introduces the results of two distinct scenarios that were conducted using this model. First, cropland asset value is evaluated when interest rates for AAA corporate bonds are 4.75%, 6% and 7% in the projection period. Second, the amount of government payments was shocked with a decrease of \$1 billion each year during projection period. A shock is an evaluation of how the system reacts to a shift in an exogenous variable. The benefit of the model is its ability to assess the effect of shocks on crop revenue, government payments, expenses, population, and interest rates, which can be analyzed with respect to cropland rent, cropland asset value, and real estate value.

Scenario 1

In the first scenario future interest rates of 4.75%, 6%, and 7% were tested. The 4.75% level is a continuation of the 2015 rate held constant in the future. The 6% level is the projection projected by IHS Global Insight. The 7% series is a gradual growth from the IHS Global Insight 6% level to 7% at which point it is held constant through the projection period. Figure 17 shows the AAA-rated corporate bond yield (interest rate) value tested in the projection period. Projections for cropland asset value and farmland real estate value were made using the alternate future interest rates. Cropland asset value results are reported in figure 18. From the graph it is evident that increasing interest rates have a decreasing effect on cropland asset value and interest levels will have a large influence on value.

Figure 17- AAA-Rated Corporate Bond Yield

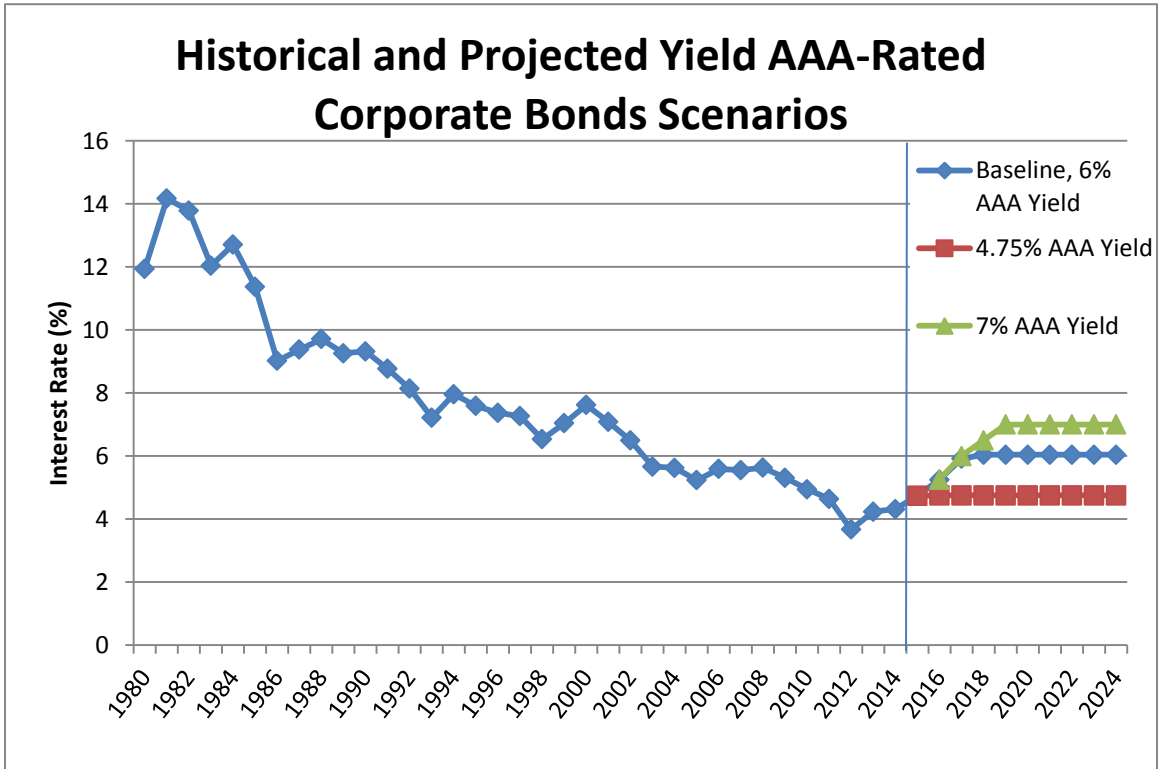
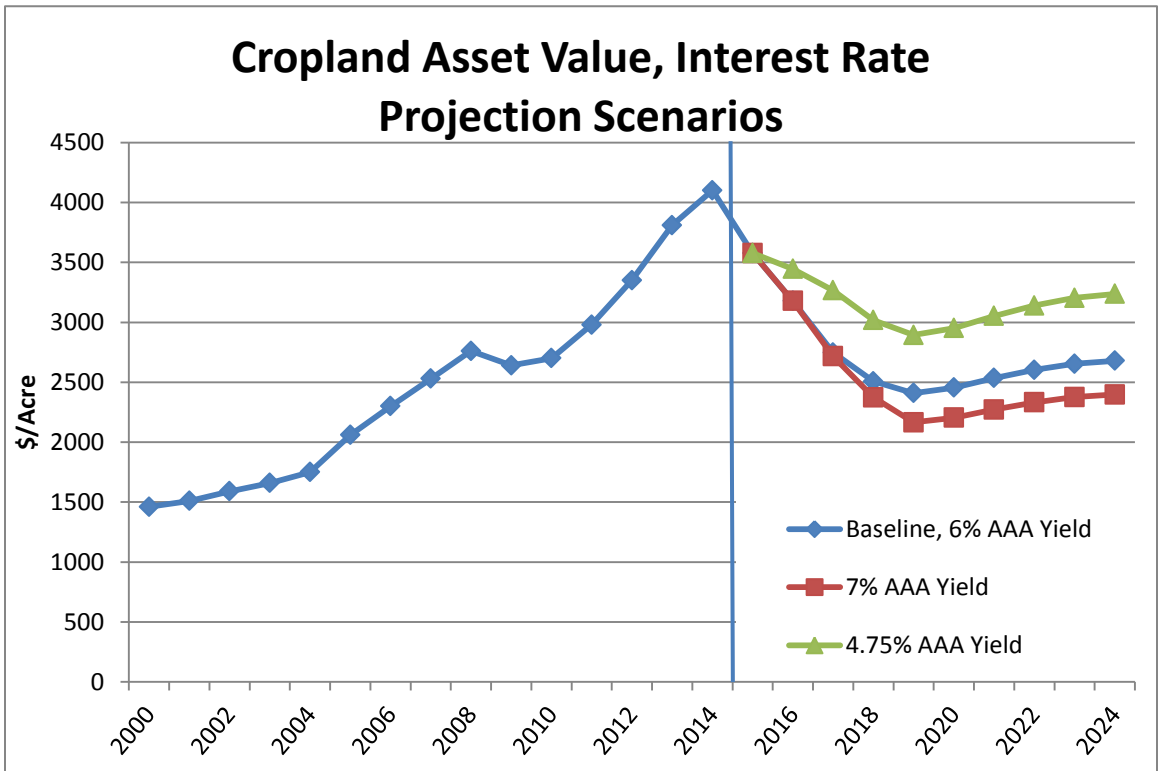


Figure 18- Cropland Asset Value, Interest Rate Scenario Baseline



Scenario 2

For scenario two (figure 19), government payments to crop producers are shocked with a decrease of \$1 billion each year over the projection period. Government payments are included in the net crop receipts variable so decreasing them will lead to a decrease in cropland rent, cropland value and farmland real estate value. The effect of the shock builds over time as a result of the 5 year moving average of the net crop receipts variable. Effects first appear in 2016, as net crop receipts affect rental rates and land values with a lag (rental rates and land values are measured at the start of the calendar year and are thus determined before a crop is planted and before returns are known).

Figure 19- Government Payment Scenario Results

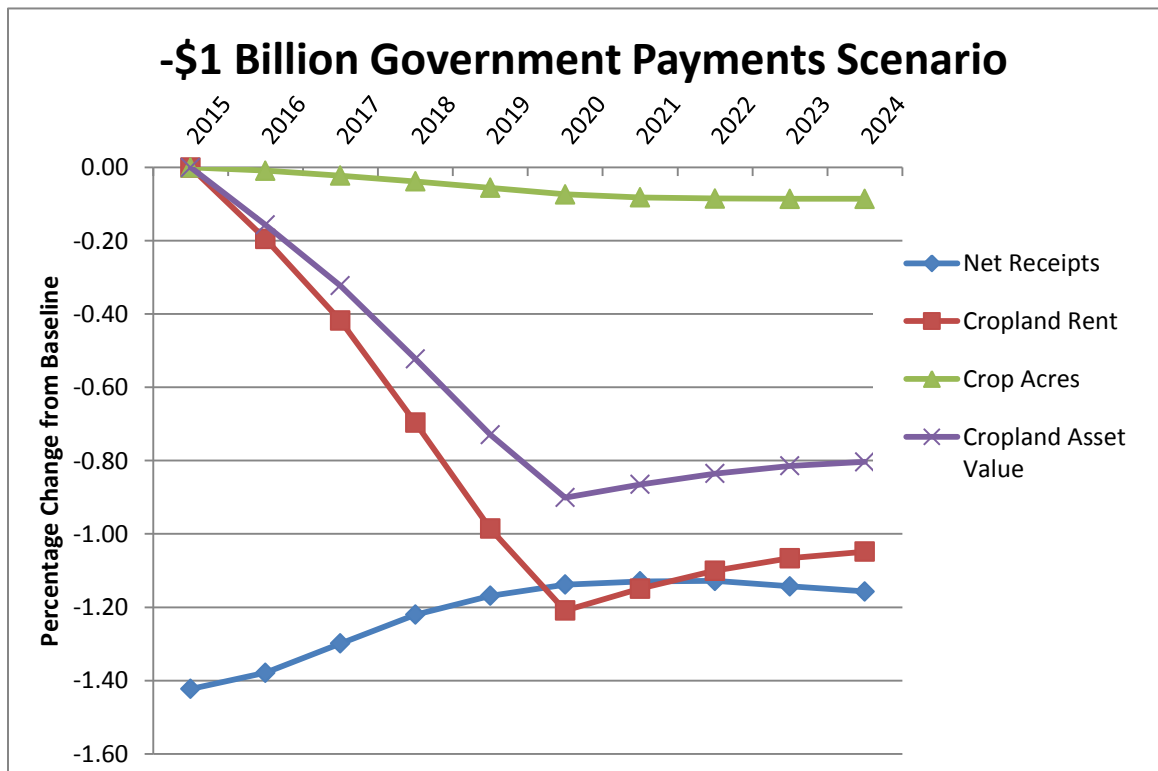


Table 10 shows the percentage decrease from the baseline of net crop receipts and the resulting percentage decreases in cropland rent, crop acres, cropland asset value, and farmland real estate value. Elasticity results from the model indicate that percentage changes in net crop receipts should have an equal effect on rent, but it will not be seen until the 5 year average lag is considered. The percentage change in cropland rent for 2020 is -1.21%, which is very close to -1.30%, the 5 year average for the percentage change in net crop receipts further supporting the finding that rental rates are unit elastic with respect to net receipts in the long run.

Table 10- Government Payment Scenario Results

Percentage Change, Government Payments Decreased by \$1 Billion										
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Net Crop Receipts	-1.42	-1.38	-1.30	-1.22	-1.17	-1.14	-1.13	-1.13	-1.14	-1.16
Cropland Rent	0.00	-0.20	-0.42	-0.70	-0.99	-1.21	-1.15	-1.10	-1.07	-1.05
Crop Acres	0.00	-0.01	-0.02	-0.04	-0.06	-0.07	-0.08	-0.08	-0.09	-0.09
Cropland Asset Value	0.00	-0.16	-0.32	-0.52	-0.73	-0.90	-0.86	-0.84	-0.81	-0.80
Farmland Real Estate Value	0.00	-0.07	-0.18	-0.33	-0.50	-0.68	-0.77	-0.79	-0.80	-0.79

From this scenario it is determined that decreasing government payments by \$1 billion each year over the 10 year projection period results in 275,000 fewer acres in crop production by 2024 than if there had been no shock. Other changes from the 2024 baseline results due to the shock include a decrease of \$1.33 per acre in the rental rate, a \$21.52 decrease in cropland asset value, and a \$17.00 decrease in farmland real estate value. It makes sense that the absolute change in cropland asset values should be a little larger than the change in farmland real estate values, as the latter includes the value of range and pastureland, which is presumably less affected by payments tied to the crop sector.

VIII. Conclusion

Past methods were considered in estimating cropland rental rate and asset values in order to develop a method that allows market decisions to be quantified. In decomposing the market a system of equations was identified that allows net crop receipts, government payments, crop expenditures, pastureland rent, population, and the interest rate to be considered as they influence cropland rental rates, crop acres, cropland asset value, and farmland real estate value.

This thesis proposed a system of five equations that culminate in a projected farmland real estate value. Similar to the early models designed by Tweeten and Martin, Herdt and Cochrane, and Klinefelter, a simultaneous equations model for the supply and demand of land-use for crop production projected a cropland rental rate. From there, the present value formula that was popularized by Alston was implemented to estimate cropland asset value. Finally a linkage equation estimated farmland real estate value from cropland asset value. In this thesis the variables can be shocked separately so that changes in cropland rent, crop acres, cropland asset value, and farmland real estate value can be analyzed.

Using projected values from IHS Global Insight and FAPRI, the equations in this model were able to project cropland rent, crop acres, cropland asset value, and farmland real estate value. The crop receipts reported by FAPRI indicated a decrease in 2015 and 2016 followed by a moderate increase through 2024. In this model a decrease in crop acres was projected over the projection period. Cropland rental rate is expected

to decrease from \$141 in 2014 to \$110/acre by 2019 and then increase to \$127/acre by 2024. Cropland asset value is projected to fall from a record high of \$4100/acre in 2014 to \$2410/acre in 2019 before beginning a slow increase to \$2680/acre in 2024.

Farmland real estate value is also expected to decrease in the production period, from \$2950/acre in 2014 to \$2055/acre in 2020, and then increase to \$2144/acre in 2024.

Once estimation was complete scenarios were run to determine the effects of future interest rate levels and the level of government payments. It was determined that the higher future interest rates are, the lower cropland asset value will be. In the second scenario government payments were reduced by \$1 billion each year of the projection period. The reduction resulted in net crop receipts decreasing 1.22% on average over the 10 year projection period. Because net crop receipts and cropland rent were found to be almost exactly unit elastic the 1.22% decrease in net crop receipts resulted in an almost equal proportional decrease in cropland rent once the system has time to adjust.

Future research could focus on multiple portions of this model. A more rigorous analysis of pastureland rent could be done to improve the future projections of the variable. Problems of autocorrelation in the estimated equations could be addressed. Crop insurance indemnities could be included in the calculation of net receipts. Research by Gutierrez, Erickson, and Westerlund could be consulted and their methods applied to this model framework to identify structural breaks in the cropland present value equation. In addition the discount rate in the present value equation should be

adjusted for inflation so that the equation can be estimated in real instead of nominal terms. The error of the system measured by the MAPE was 12% for farmland real estate value. Improving the present value estimation could reduce a large portion of the error, but eliminating all error is impossible. This model can be improved and adopted into systems that need projected cropland rent, cropland asset value, and farmland real estate value in order to analyze farm equity and the future health of the farm sector.

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